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THE

HISTORY AND DESCRIPTION

OF

FOSSIL FUEL,

THE COLLIERIES,

AND

COAL TRADE OF GREAT BRITAIN.

BY THE AUTHOR OF THE

"TREATISE ON MANUFACTURES IN METAL,"

(THREE VOLUMES,) (J. Holland)

IN LARDNER'S CABINET CYCLOPÆDIA.

"COAL — ONE OF THE MOST USEFUL OF ALL THE PRODUCTIONS OF THE EARTH WHICH IT HAS PLEASED THE ALMIGHTY TO PROVIDE FOR THE USE OF MAN."—*Petition to Parliament, from Staffordshire Collieries.*

LONDON:

WHITTAKER AND CO., AVE MARIA LANE;

AND G. RIDGE, KING-STREET, SHEFFIELD.

1835.

PREFACE.

In presenting this Work to the public, the Author has to bespeak the indulgence of certain classes of individuals, whose anticipated gratification he can only hope to have partially succeeded in realizing: he alludes to those who may happen to be professionally engaged in any of the branches of science or business touched upon in the following pages. Should it, therefore, be discovered that the writer of this treatise is neither a Geologist, a Collier, nor a Coal Merchant, the harshness of criticism may surely be deprecated, until some one avowedly possessing such threefold qualification shall compile a volume better adapted than the present for popular instruction, and more accurately conformable to the present state of knowledge in reference to the various matters discussed.

That the subject is an interesting one, few persons, it may be presumed, will deny: indeed, this fact is abundantly illustrated by the importance attached to disquisitions on one branch of it, by

geological writers—to another of its bearings, by the legislature—and to the third, by the whole community: for the origin and position of our stores of fossil fuel have abundantly exercised the learning of the first class; the regulation of its vend at home and abroad, the attention of the second; and the economical application of it, is confessedly of transcendent importance to the third class—comprising, as it also does, both the others.

On these grounds, the writer—whose literary avocations have brought him into contact with cognate inquiries, and who, on other accounts, may perhaps be allowed to presume he is not quite unqualified for the task—thought that a comprehensive but somewhat compendious notice of the whole subject, as announced in the title-page, and arranged as a sort of monograph, while it would be convenient and useful for the library in general, could hardly fail to be acceptable to many persons who, without wishing to push their inquiries into those voluminous publications through which the matter lies scattered, much less who think of embarking capital in the coal trade on the credit of any literary recommendation, might nevertheless be glad to meet with a succinct description of what has been done in the various departments, and the bearing of which is actually so important.

Changing the person, and adopting the sentiment of Mr. Williams, who, in 1789, published at Edinburgh a *Natural History of the Mineral Kingdom*, written in a quaint and prolix style,—"I am really concerned for the honour of the coal: it is an interesting subject, especially in Britain;"—I cannot, however, entirely adopt the next member of the sentence, correct as it may have been half a century ago—"and, as very little to the purpose has been said about it hitherto, that I know of, I reckon the subject my own, and therefore," adds our author, "I wish to be its faithful historian." Entertaining, as I have done, this laudable wish, and having laboured—surely not without some success—to realize it in these pages, I cannot justly complain either of a paucity of materials, or of those not being to the purpose: my only apprehension is, lest I may have been unfortunate enough in some instances to have overlooked, or unsatisfactorily to have exhibited, such as were the most excellent.

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CHAPTER I.

INTRODUCTORY—FIRE AND FUEL.

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FIRE, according to the old writers, is one of the four primary qualities or conditions of matter, or in other words, that elementary substance which has the property of devouring other bodies,—the other three elements, according to the ancient theory, being air, earth, and water: to speak more philosophically, it is that subtle substance by pervasion with which bodies are rendered hot to the touch, and, if previously solid, become at a certain temperature fluid, and are afterwards either carried off in vapour or melted into glass: or by the application of which, fluids, as commonly spoken of, are rarefied into vapour. In the most

ordinary sense, Fire is understood to mean matter in a state of combustion or incandescence: and it is in this acceptation more particularly, that the term is used in the present work. During the eighteenth century, the supposed general principle of heat, or inflammability, was called phlogistion, a term invented to suit the theory of Stahl, which assumed and thus designated such principle, as a constituent element of all combustibles. But Lavoisier, who died in 1794, introduced a new theory, depending on the existence of what is called caloric, a denomination universally adopted by modern chemists. It assumes that combustion is caused by the combination of the oxygen of the atmosphere, not with hydrogen, or with the imaginary substance of phlogistion, but with the combustible itself, and that in such combination light and heat are produced.* It would be out of place in a work like the present, to enter into any lengthened investigation of the nature of this agency to which the phenomena of light and heat are ascribed; or in what respects it seems to fail to account for some existing facts. It may be remarked, however, that by one class of theorists, heat has been hypothetically regarded as a fluid of inappreciable tenuity, whose particles are endowed with indefinite ideo-repulsive powers, and which, by their distribution in various proportions among the particles of ponderable matter, modify cohesive attraction, giving birth to the three general forms of gaseous, liquid, and solid.† Another class of philosophers, among whom ranks the celebrated Sir Humphrey Davy, have doubted the separate entity of a calorific matter, and have adduced

* Lardner's Treatise on Heat, p. 365. † Dr. Ure.

evidence to shew that the phenomena might rather be referred to a vibratory or intestinal motion of the particles of common matter. Under no circumstances, notwithstanding that philosophers have paid the minutest attention to the subject, does it appear that the communication of heat has ever been found to make any appreciable addition to the gravity of the matter pervaded by it, which, if it were a substance *sui generis,* we might be led to expect. Dr. Lardner, however, remarks that "the material theory has the advantage of offering an easily intelligible explanation of the phenomena of heat, so far as it is at all applicable or satisfactory. On the other hand, the vibratory theory is involved in the difficulty of requiring more acute powers of mind to apprehend its force, or even to understand any of its applications. Indeed, it would scarcely admit of full exposition without the use of the language and symbols of the higher Mathematics; but, perhaps, the strongest support which the vibratory theory can derive, is from the facts which render it probable that light and heat are identical. If," adds the Doctor, "the identity of heat and light be admitted, then the question of the nature of heat is removed to that of light, respecting which two theories have been proposed, precisely similar to those of heat; viz., the corpuscular and the undulatory theories. Both of these theories serve to explain the bulk of optical phenomena; but some effects, discovered by modern investigation in physical optics, are considered to be more satisfactorily explained by the undulatory theory: the question, however, remains unsettled."* From an examination of these

* Treatise on Heat, p. 398.

and other theories, enough will be learned to shew how little room there is to pronounce dogmatic decisions on the abstract nature of heat. But, as Dr. Ure justly remarks—if the source of the cause be still involved in mystery, many of its properties and effects have been ascertained, and skilfully applied to the cultivation of science and the uses of life.

The primary sources of fire are very various in their technical sub-divisions: they may, however, be generally included in the following distribution, comprising those that may be termed natural, as well as those that are artificial:—1. The Sun.—2. Lightning.—3. Chemical combinations.—4. Friction or collision.

1. The most obvious source of igneous action with which mankind has always been familiar, is undoubtedly that orb from whence our earth is indebted for light and heat. It is not, indeed, probable that the earliest fires kindled by the progenitors of the human race were derived immediately from this luminary—as they could not be acquainted with the method of collecting its rays by the burning glass, nor of concentrating them by the concave mirror: it is now, however, well known, that in some parts of the world vegetable and other matters may be in a state of dryness and inflammability, sufficient to allow them to become ignited by the mere action of the solar heat upon them.

2. Lightning, although happily for mankind not a common agent of terrestrial inflammation, is much less rarely so than the sun. While the instances of combustion through the influence of a *coup de soleil* strike us as uncommon, not a year passes but we hear of the fatal or destructive consequences of what

is called, with equal poetry and truth, by the common people, the "falling of the thunderbolt:" and although a sudden consumption, torrefaction, or at least piercing, of the object stricken, is the more usual phenomenon, yet the works of man, forests, and even beds of coal, are sometimes set on fire by the electric flash.

3. The most remarkable, active, and violent local sources of fire on the large scale of nature are, however, those vast magazines of chemical action—volcanoes. At what period man first became acquainted with the outbreaks of these tremendous laboratories of nature, or how nearly he at first approached them, we do not know: we have, however, accounts of eruptions which date from a very remote antiquity; and, according to some theorists, these reservoirs of central fire are coeval with the present formation of our planet—the earth being, in fact, according to Whiston, an extinct comet, the crust of which has cooled down to its present temperature, while the core is still in a state of fusion. Akin to this notion, is the theory of that class of geologists called the Plutonists, who contend that the greater dislocations of the various strata of which, so far as we know, the earth is composed, and the various combinations into which these have obviously entered with each other, are attributable to igneous action, in opposition to the Neptunists, or disciples of Werner, who pretend that water has been the principal agent in the production of those phenomena which it is in the province of the geologist to investigate and classify. To say nothing of those scientific contrivances by means of which Modern Chemistry has furnished the world with so many sources from which fire may be derived,

it is well known that sulphureous or bituminous exhalations, or what may be called "fountains of fire," exist in various parts of the world; and although the matter of these gaseous vents is more frequently inflamed by art, yet there seems no reason to doubt but that they may have been occasionally lighted by a concurrence of natural causes, and even have offered to man some of the earliest opportunities for transferring ignition to a more substantial pabulum; as well as afforded those flames, at which was very early lighted the torch of superstition.

4. As, however, we find that the process of procuring fire by many savage nations at this day is by rubbing two pieces of dry wood together until they inflame by the friction, so we may presume that this would be the original method resorted to for the artificial procuration of fire in the first ages of the world. This effect, indeed, if we may believe ancient authors, has sometimes been produced by the operation of natural causes, and that too on a large scale: for they tell us of the conflagration of forests by the violent rubbing together of the tall trunks of resinous trees during strong winds.* The quaint old French poet, Du Bartus, who found a most doggerel English translator in Joshua Sylvester, at the beginning of the reign of James I., has, in his "Devine Weeks

* Conflagrations from the cause alluded to, appear to be far from uncommon in some parts of India. The Rev. H. Caunter, describing a fire which swept up the sides of the mountains skirting the Coaduar Ghaut, near Calcutta, forming a sea of fire to the extent of several miles, informs us, that "this striking phenomenon is not by any means uncommon, and is accounted for by the larger bamboos, as they are swayed by the wind, emitting fire from their hard glossy stems through the violence of their friction, and thus spreading destruction through the mountain forests."—*Oriental Annual*, 1835.

and Works," a curious passage describing "*how the first man invented fire, for the use of himself and his posterity.*" The passage is prolix; but the fancy which represents Adam and Eve as approaching so nearly the invention of the tinder-box, has thrown an air of singularity over the story, sufficient to repay its perusal. Our first Parents having been cast out of Paradise, had, according to the poet, made themselves a dwelling;—

> "Yet fire they lack't: but lo, the windes that whistle
> Amid the groues, so oft the Laurell iustle
> Against the Mulbery, that their angry claps
> Do kindle fire that burns the neighbour cops.
> When Adam saw a ruddy vapour rise
> In glowing streams; astund with fear he flyes,
> It follows him, vntil a naked plain
> The greedy fury of the flame restrain:
> Then back he turns, and comming somwhat nigher
> The kindled shrubs, perceiving that the fire
> Dries his dank cloathes, his colour doth refresh,
> And unbenums his sinews and his flesh;
> By th' vnburnt end a good big brand he takes,
> And hying home a fire he quickly makes,
> And still maintains it till the starry twins'
> Celestial breath another fire begins.
> But Winter being comm again it griev'd him,
> T' have lost so fondly what so much reliev'd him,
> Trying a thousand ways, sith now no more
> The iustling trees his domage would restore.
> While, elsewhere musing, one day he sat down
> Vpon a steep rock's craggy forked crown,
> A foaming beast come toward him he spies,
> Within whose head stood burning coals for eyes:
> Then suddainly with boisterous arm he throwes
> A knobbie flint that hummeth as it goes;
> Hence flies the beast, th' il-aimed flint-shaft grounding
> Against the rock, and on it oft rebounding,
> Shivers to cinders, whence there issued
> Small sparks of fire no sooner born than dead.

This happy chance made Adam leap for glee,
And quickly calling his cold companie,
In his left hand a shining flint he locks,
Which with another in his right he knocks
So vp and down, that from the coldest stone
At every stroak small fiery sparkles shone.
Then with the dry leaves of a withered bay
The which together handsomely they lay,
They take the falling fire, which like a sun
Shines cleer and smoakless in the leaf begun.
Eve, kneeling down, with hand her head sustaining,
And on the low ground with her elbow leaning,
Blowes with her mouth : and with her gentle blowing
Stirs up the heat, that from the dark leaves glowing,
Kindles the reed, and then that hollow kix
First fires the small, and they the greater sticks."

The accounts given by Cook and other circumnavigators, of the method practised by the South Sea Islanders for obtaining fire by friction, have been abundantly verified by recent voyagers. The following exceedingly intelligible description of the process as practised at Tahite, is from the "Journal of Voyages and Travels by the Rev. Daniel Tyerman and George Bennet, Esq. in the South Sea Islands, &c." compiled by Mr. Montgomery. "We had an opportunity," say the Journalists, "of observing the simple and ingenious process by which the islanders obtain fire. A man took a piece of dry purau wood, twelve inches long, and two thick. With another stick of the same tree, sharpened to a point, and held with both his hands, at an angle of about 45°, he rubbed the former gently, as it lay on the ground, till he had scratched a groove in it several inches long. Then continuing the same operation, but pressing the point harder upon the lower piece, and increasing the velocity of the motion, some brown

dust was soon formed within the groove, and collected at one end. In a few seconds smoke was apparent, and the dust was ignited. The spark was then immediately conveyed into a finger-hole opened in a handful of dry grass. The man blew upon it, and waving the tuft in the air, the grass was quickly in a flame. The whole experiment did not occupy more than two minutes."*

Various as are the sources from which fire may be obtained, the purposes to which it has been applied are inconceivably more diversified. To enumerate all these purposes would be impossible: it may, however, be interesting to mention the heads, to one or other of which most of the objects in lighting up artificial fires may be referred:—

I. In connexion with Religion:

II. For culinary purposes:

III. For promoting personal comfort by means of warmth: and

IV. For the various operations of Metallurgy and the Arts.

I. Under the first of these heads we are called upon to notice the application of fire for a purpose infinitely different from the three that follow, and also to recognise a derivation of the element not in the slightest degree referable to any of the before-mentioned sources;—we allude to the consuming of the animal sacrifices under the Patriarchal and Mosaic institutions of the Old Testament, by "fire from

* Other authorities describe the plan as consisting in giving a rapid motion to a pointed stick, in the manner of a vertical spindle; by neither method, however, does it appear that Europeans have been able to effect that which they saw the savages so readily accomplish.

heaven." It is probable that the fire which was kept burning on the altars in the Temple at Jerusalem was so derived,* as the element visibly descended and consumed the sacrifice when the LORD made a covenant with Abraham, when Moses dedicated the Tabernacle, and when Solomon dedicated the Temple: it was always considered sacred, and the offering with "strange fire" was considered an abomination in the sight of JEHOVAH. Besides its important application as an auxiliary in the Hebrew sacrifiture, fire became an object of actual worship with several Gentile nations in the East. The Chaldeans accounted it a divinity; and in the province of Babylon there was a city called Ur, or of fire, consecrated to this usage. The Persians also adored GOD under the similitude of fire, because it is fire that gives motion to every thing in Nature: they had temples called Pyrœa, or fire temples, set apart for the preservation of the sacred element. The priests among the Persian fire-worshippers are called Ghebers, and a splendid chapter is devoted to the subject of their mysteries in Moore's exquisite poem of "Lalla Rookh." They are said to have fires at present subsisting among them that have been burning several thousand years.† In Old Rome, fire was worshipped in honour of the goddess Vesta, and virgins called vestals were ap-

* Catholic writers tell us, that on Good Friday an interdiction ensued in the Romish Church, and all the fires were totally extinguished. Consequently, it was usual to provide charcoal on Easter eve, for renewing the fires on Easter day; when, however, they were kindled again, it was done by elemental fire produced by flint and steel, and not from unhallowed embers. From this fire, the *Paschal-taper* was also lighted.

† So superstitiously do the Parsees regard the element of fire, that if a conflagration breaks out, instead of endeavouring to quench it with water, they pull down the houses liable to be consumed, that the fire may go out for want of combustible matter to feed it. In their temples they keep fires of the most costly woods constantly burning.

pointed to keep it up. Other nations,* as the Gauls, and some of the aboriginal American tribes, paid veneration to fire.

II. The earliest application of fire for civil or domestic uses, would undoubtedly be in the cooking of victuals: for no nation has hitherto been discovered in such a state of barbarism as to be unacquainted with the arts of procuring and the culinary application of fire. Man, indeed, among many other whimsical definitions of the genus *Homo*, has been called "a fire-making animal," because it has been asserted that he of all creatures is capable of procuring, keeping up, and turning to account factitious combustion. Although lighting fires and waving brands are among the means adopted to frighten away wild beasts from the presence of man, many of the inferior animals are known to be exceedingly fond of artificial warmth; but they have no instincts conformable to the means of procuring it for themselves. Even apes, the most sagacious imitators of the actions of man, fond as they generally are of basking near a fire, appear to have no instinct which leads them to rake together the embers, or add more fuel to prevent it from expiring. This may be regarded as an obviously wise arrangement of Providence; for had that mischievous disposition which so commonly charac-

* Among the Hindoos, a great number of mystical ceremonies and invocations are referred to Paraki as the regent of fire. This fire-king is, however, more commonly worshipped under the name of Agni; and the following, according to the institutions of Menu, is one of the common Brahminical invocations of that deity:—"Fire! Seven are thy fuels; seven thy tongues; seven thy holy sages; seven thy beloved abodes; seven ways do seven sacrifices worship thee; thy sources are seven; may this oblation be efficacious!" An explanation of this mysterious passage has been given by Mr. Colebrooke, in his Essay on the Religious Ceremonies of the Hindoos, in the seventh volume of the "Asiatic Researches."

terises the *Simia* species, been extended to a fondness for playing with ignited matters, the consequences might have been disastrous indeed; for what meddlesome monkey would not have been liable, could he have picked up a lighted brand, to have become the Erostratus of his own particular forest! *

III. The use of fire for the purpose of promoting personal comfort, by raising the temperature of some portion of the surrounding atmosphere, although coextensive with its application to the cooking of victuals in our own and several other countries, is nevertheless by no means of so common occurrence in tropical and other warm climates. In Northern Europe, Asia, and America, the amount of fuel consumed for this purpose alone is prodigious; and, certainly, no where more than in England, is the luxury of what are called "good fires" carried to an extent which, independently of other considerations, renders the subject discussed in the following pages one of paramount importance in a commercial, as well as physical, point of view. Every dwelling-house in the kingdom, however small or poor—and, it may be added, nearly every temple of religion, as well as every shop, mill, and manufactory—each has its appropriate apparatus for keeping up internal warmth, and is for the most part thus linked to the importance of the coal trade. It modifies, indeed, but does not

* It has indeed been said, that the tall monkeys of Borneo and Sumatra not only lie down with pleasure round any accidental fire in their woods, "but," it is added, "they are arrived to that degree of reason, that knowledge of causation, that they thrust into the remaining fire the half-burnt ends of the branches, to prevent its going out." The reality of this fact, especially as connected with "that knowledge of causation" which is just mentioned, appears more than doubtful.

destroy, the importance of this connection, whether the modern modes adopted for heating be regarded as consisting of any of the innumerable varieties of stoves, hot-air vessels, steam machines, or the more recent contrivances for warming apartments by means of pipes circulating water in a state of ebullition—all are dependent upon the combustion of more or less of ignited matter in the state of fuel.

IV. The most important application of fire, however, is in the smelting of ores, the working of metals, and the carrying forwards those chemical operations on a large scale, for which Great Britain and several other countries are so celebrated. The knowledge of the effect of heat in separating metallic particles from the earthy or other masses in which they might be found embedded, is of the highest antiquity; and from the days of Tubal Cain, "the first instructor of all artificers in iron and brass," to the present time, mankind have attached increasing importance to metallurgic operations, and to the arts depending thereupon. And, not only from the records of the earliest ages, but from almost every section of the globe inhabited by man, whether in a savage or a civilized state, we derive fresh materials for evidence in illustration of the dominion which human industry and ingenuity have sought to establish over the mineral kingdom by the agency of fire. Some particulars relative to the different substances used as fuel, may appropriately close this Chapter.

Of the agents of combustion, as defined by the strict nomenclature of Modern Chemistry, it is not necessary, in this place, to take farther notice than briefly to remark that some of these four substances—oxygen, chlorine, bromine, and iodine—being, almost

in every case, one of the two bodies by the combination of which combustion is produced, and the other matters with which they severally combine being far more numerous, the four just mentioned are distinguished, relatively to the phenomena of combustion, by the name *supporters of combustion;* while the other body forming the combination with them, whatever it may be, is called *a combustible.**

Reverting to less scientific phraseology, it may be remarked, that, whatever substance is either capable of being inflamed, or of remaining in a state of incandescence, may come, in a certain sense, under the denomination of fuel. Hence, certain liquids, as alcohol, oil, &c., with all resinous, bituminous, and fatty matters on the one hand; and on the other, several fossil productions, with the intermediate varieties of structure, and ligneous bodies in general, may be at once referred to, as comprising the classes of bodies commonly used as supporters of combustion. Inflammable fluids, in any place, are more rarely used for the production of heat than of light; and in this country, purely bituminous products are almost as seldom applied, by themselves, to the purposes of firing: in some parts of the world the case is widely different. Large quantities of naphtha are obtained on the shores of the Caspian sea; and the inhabitants of Baku, one of its ports, are supplied with no other fuel than that obtained from the naphtha and petroleum, with which the neighbouring country is highly impregnated. In the island of Wetoy, and on the peninsula of Apcheron, this substance is said to be very abundant, supplying immense quantities which

* Lardner's Treatise on Heat, p. 355.

are carried away.* The inhabitants of other parts of the world, in the vicinity of Asphaltum springs, have recourse to the like substances for the purposes as well of cooking as of illumination; for which objects, also, the springs of natural gas are sometimes economically applied.

Among some of the eastern nations, the dung of the camel and other herbivorous animals is carefully collected and dried for fuel. A number of curious particulars illustrative of this fact as regards the Jews, are collected by Harmer.† A similar practice formerly prevailed in some of the midland counties of this kingdom.‡

Animal matter is sometimes, though rarely, used as fuel. The Arabs, however, who dwell in that part of their country bordering on Egypt, must be regarded as forming in some degree an exception to the remark; for they draw no inconsiderable portion of the fuel with which they cook their victuals from the exhaustless mummy-pits, so often described by travellers. The extremely dry state of the bodies, and the inflammable nature of the matters with which they have apparently been saturated, during the process of embalming, render them exceedingly convenient for the above purpose. We have a still more striking instance: wood was formerly so scarce at Buenos Ayres, and cattle so plentiful, that sheep were

* Edin. Phil. Journal, vol. v.

† It is from the soot collected during the combustion of this fuel that the Egyptians procure *sal-ammoniac*, by simple sublimation.

‡ The droppings of the cows were collected into heaps, and beaten into a mass with water: then pressed by the feet into moulds like bricks, by regular professional persons, called clatters (clodders); then dried in the sun, and stacked like peat, and a dry March for the clat-harvest was considered as very desirable.—*Journal of a Naturalist.*

actually driven into the furnaces of lime-kilns, in order to answer the purposes of fuel. This fact could hardly have been mentioned as credible, however undoubted, if a decree of the King of Spain, prohibiting this barbarous custom, were not still preserved in the archives of Buenos Ayres.

The inhabitants of the sea-coasts, who happen to be remote from better fuel, or too poor to obtain it, collect sea-weed *(Fucus vesiculosus, Linn.)* and such like stuff for firing—an indifferent enough material for the purpose, as may readily be supposed. In the Norman Isles, sea-weed is assiduously gathered by the inhabitants, both for fuel and manure: it is called in French *varech,* and in the Jersey dialect " vraic."*

The most convenient, and happily the most abundant, kinds of fuel known in this and most civilised countries, are peat, dried wood, charcoal, and fossil coal, either in the state in which it is raised from the mine, or in the condition of coke. The history of peat, as immediately coming within the design of the present work, will form the subject of the next Chapter; while wood fuel will be subsequently adverted to, in connection with those vicissitudes to which the iron and other trades in this country were exposed, during their transition from a dependence upon our decaying forests, to those inexhaustible depositories of coal, descriptions of the history, working, and commercial importance of which can scarcely fail to impart a lively interest to the ensuing pages.

* The season of collecting this substitute for coal and firewood is made a season of merriment in Jersey; the times of vraicking are appointed by the island legislature, and then multitudes of carts, horses, boats, and vraickers cover the beach, the rocks, and the water.—*Inglis's " Channel Islands,"* vol. i. p. 99.

CHAPTER II.

GEOLOGICAL THEORIES.

Interesting character of Geological Science—Extent of knowledge required for successful investigation—Controversies and conflicting theories—Important connexion between Geology and Revelation—Question of progressive developement of Species—Hutton and Werner—Subterranean temperature—Paroxysmal and Cataclysmal Eras of MM. Beaumont, Brongniart, and Cuvier—Jameson's Remarks—Mineral and Mosaical Geologies contrasted—Fairholme—Theory of Werner—Tabular view of the positions of Strata—Formations—Gradation of Fossils of vegetable origin.

THE science of Geology, a science still in its infancy, has been pursued of late years with an ardour commensurate to the importance of its bearings in relation to the physical structure of the earth, no less than as developing a series of phenomena of the most striking and interesting character. Nor is the study of this comprehensive subject at present confined in its scientific attractions to divines and philosophers on the one hand, nor on the other hand is it left to miners and metallurgists alone to estimate its practical im-

portance. It has become essential to a liberal education, that a man know something of the stratification of the globe upon which he lives, and to the fossil and mineral riches of which he is so largely indebted. Even under the softer designation of an accomplishment, some acquaintance with the principles of Geology is not unfrequently acquired by individuals of both sexes as a source of elegant intellectual recreation. Formerly, indeed, the few learned men who paid attention to this science, if science it could then be called, did so, either as the devisers and defenders of capricious theories, or as the champions or opponents of revelation, just as those theories were considered favourable or inimical to the Mosaic accounts of the Creation and the Deluge. To these learned controversies it is unnecessary farther to allude, as the present remarks are intended merely to introduce such a brief glimpse of geological doctrines as may enable the general reader, in some degree, to understand the relative position of the beds of mineral coal among those numerous and diversified strata, with which the investigations of art and science have made us acquainted.

The study of Geology in the extended sense, and as the subject is treated by recent writers, such as De la Beche and Lyell, particularly the latter, whose voluminous work is extremely interesting,—requires a comprehensive knowledge of geography, meteorology, anatomy, conchology, botany, and natural philosophy in general. For it is only to persons somewhat conversant with the manner in which these and numerous other branches of physical investigation are made to bear upon the modes of accounting for various phenomena, discoverable in the present and recorded of

past states of the earth's crust, that the interest of the science can be rendered greatly apparent. The elevation of mountain-masses, the formation of valleys, the recession or encroachment of the sea, the phenomena of rivers and lakes, the activity of volcanoes, thermal springs, and the operation of numerous other causes, give rise to speculations which call forth the most ample resources of knowledge for their support, elucidation, or correction.

In the developement of phenomena consequent on these enquiries, it is certainly not surprising that the reverers of the most ancient and authentic historical document in the world, should at all times have felt sensibly alive to whatever was put forth as evidence on this subject, whether appearing to confirm or to oppose the sacred cosmogony of the Book of Genesis. It must be admitted, however, that the advocates of the integrity of the sacred record have sometimes committed themselves and their righteous cause, by the exercise of a zeal not according to knowledge. Their error, to speak of it comprehensively, has been twofold: in the first place, they have hastily confided the sustentation of the credit of the Mosaic account to one plausible hypothesis or another, and these failing, by the discovery that their foundations were not laid in physical facts, the enemies of revelation have assumed, still more unwarrantably, that the whole fabric of Divine Truth must be one of equal instability: in the second place, they have too often spoken and written as if, admitting the inspired authenticity of a passage, we are compelled to adopt as infallible its commonly received interpretation. This is, confessedly, a delicate point, and one in all disquisitions connected with which too great a degree of precaution

cannot be exercised; but it must be exercised on the part of the divine as well as the geologist; for, while the latter produces facts, apparently in overwhelming abundance, to shew that certain notions long entertained may possibly be unfounded, and submits that the advocates of revelation act unwisely in forcing interpretations at variance with phenomena,—the former has no right to place an issue of so much importance to mankind as the credibility of the Bible History, on the very dangerous presumption that no scheme of explanation, no method of reconciling seeming discrepancies, surpassing his own, can ever be attained to.

Let it not be supposed for a moment, from what is here said, that it is intended to undervalue the labours of those who have sought to reconcile the modern discoveries in Geology with the commonly received interpretations of the Mosaic accounts of the creation and the deluge; much less to throw any slight on the successful efforts of those who have shewn what may be accomplished in this way; nor, least of all, let it be imagined that any apprehension is entertained, as if the testimony of physical phenomena can ever be opposed to the spirit of divine revelation. A competent authority has declared, that "the facts developed by Geology are consistent with the accounts of the creation and deluge, as recorded in the Mosaic writings." * It is against that presumptive principle which strives to make theology and physics, studies essentially distinct, the vehicles of perpetual reprisal, that the present caution is directed.

A passing allusion to the systems of Hutton and

* Buckland's Vindiciæ Geologicæ.

Werner, usually recognised as the Plutonian and the Neptunian, from the paramount importance attached by the one to the agency of fire, and by the other to that of water, in the formation of our globe, has already been made in the preceding Chapter. The absurd lengths to which some of the abettors of these conflicting theories have occasionally gone, in deriving plausible generalizations from insulated or local phenomena, have taught modern geologists a useful lesson; and the man would now be thought insane who, overlooking the multitudinous examples of the undoubted agency of both causes on a large scale, should invoke, for the explanation of all difficulties, the genius of either fire or water exclusively. Many of the phenomena of the rocky masses exhibit unequivocal traces of their double origin—in the one case of refrigeration from igneous fusion, and in the other of concretion from aqueous solution. While some philosophers have assumed, that the central nucleus of our globe is in all probability ponderable matter in a condition of amazing density, others have imagined a cavity filled with water; and an American speculatist believed it to be hollow, and even accessible from the extreme north. Whatever be the matter occupying the "centre of our sphere," it may be presumed to exist in a state of such prodigious compression, as to present conditions little if at all analagous to matter in any mode with which we are acquainted with it.

The long-agitated question as to whether the temperature of our planet increases towards the centre or not, has received little illustration from facts: the assertion, therefore, that the increment of temperature corresponds on the average to about 1° Fahrenheit for

every seven fathoms of descent, rests rather on theory than experience. It must be obvious that thermometrical results obtained in mines, with the utmost precaution, are very liable to prove fallacious;—conducted, however, by skill and experience, they may become of importance.*

With reference to the great outlines of two conflicting geological theories, to which more especial attention has been excited of late, it may be briefly observed, that one, and that the longest and most generally entertained, assumes the creation of the matter of our globe to have taken place about six thousand years ago; that in six days, of twenty-four hours each,† it was not only modified into terrene, aqueous, and aërial relations, but also replenished with vegetable and animal life; subsequently to which primeval settlement, it has undergone one great catastrophe by water;—and that this, along with the

* For a series of interesting experiments of this class, made by John Phillips, Esq., F.G.S., in one of the deepest mines in the world, and under very favourable circumstances, vide *London and Edinburgh Phil. Journ. Dec.* 1834.

† The well-known American Professor Silliman has put a question which is intended as an *experimentum crucis* for the interpretation adverted to. "Supposing," says the Professor, "that there are inhabitants at the poles of the earth, how must they understand the days of the creation? To them a day of light is six months long, and a night of darkness six months long; and the day, made up of night and day, covers a year; and it is a day, too, limited by morning and evening. Such persons, therefore, must suppose, upon the literal understanding of the days of creation, that at least six years were employed upon the work. So also at the polar-circles, there is every year one day—that is, one continued vision of the sun for twenty-four hours and one continued night of twenty-four hours: while every where within the polar-circles, the days and the nights respectively are for six months more than twenty-four hours, extending even, as we advance towards the poles, through the time of many of our days and nights. How are the inhabitants of these regions to understand the week of the creation, if limited to the literal interpretation of the inspired record?" Surely the above is philosophical trifling, to designate it by no harsher a term. Do the Laplanders ever regard the period of absence of the sun during their winter as the measure of their night?

operation of causes still going on, are sufficient to account for all the phenomena observed in the present structure of the earth. The other theory, inferring from the appearance and situation of certain fossilised organic reliquiæ, a much higher antiquity as to the origin of our planet, admits the creation of man, and perhaps of the animals which now surround him,* at the period commonly assigned, and even recognises the great diluvial event announced in the Bible; but it likewise assumes a progressive developement of organised existence,† and contends for a succession

* It is a remarkable circumstance, and one which has been taken as corroborative of the hypothesis of the transcendant antiquity of certain deposits of the reliquiæ of the simplest types of animal organization, that the remains of human beings are no where found embedded, even among the reliques of the more perfect mammalia, until we come to the strata of comparatively recent origin. Skeletons of men, more or less mutilated, have been found in the West Indies, on the coast at Guadaloupe. One of these fossil skeletons is in the British Museum, and another in the Royal Cabinet at Paris. The antiquity of these remains has given rise to some discussion: but the ablest geologists assign them to a modern era. The rock in which they are enclosed is known to be forming daily; it consists of minute fragments of shells and corals, incrusted with a calcareous cement resembling travertin, and altogether not unlike the red conglomerate of the rock of Gibraltar, so full of the bones of apes, &c. While the absence of human remains in the older strata is admitted, it must not at the same time be forgotten, that those regions where the human family is believed to have originated, and over which its descendants first spread themselves, have been little explored by geologists. This circumstance has been dwelt upon by Mr. Lyell, who has also adverted to the consideration that, as there is no reason why the bones of men should, under any circumstances, be less imperishable than those of quadrupeds, with which they are sometimes found well preserved in peaty, fluviatile, and other recent stations, "we do not despair of the discovery of such monuments, whenever those regions which have been peopled by man from the earliest ages, and which are at the same time the principal theatres of volcanic action, shall be examined by the joint skill of the antiquary and the geologist."—*Principles of Geology*, ii. 265.

† The theory of progressive perfectability has been most ingeniously and indefatigably carried out by the celebrated French naturalist Lamarck, in his Zoological system. He remarks, that if we examine the whole series of known animals, from one extremity to the other, when they are arranged in the order of their natural relations, we find that we may pass progressively, or at least with very few interruptions, from beings of more simple to those of

of catastrophies by means of which the primitive forms have been overthrown and entombed many thousands of years before the advent of the first human pair. Of course, this theory requires us to concede, at least, that the first verses of the Mosaic account must bear a much looser interpretation than that which is usually given to them; and it is mainly to the views taken as to the importance or non-importance of such concession, that we must attribute the *animus* of many of the discussions on either side.

The question is confessedly important; and even Werner himself, whose system is now chiefly recognised in Europe, is said, on the testimony of one of his distinguished disciples,* to have expressed himself, "out of respect for the Sacred Scriptures," cau-

more compound structure; and in proportion as the complexity of their organization increases, the number and dignity of their faculties increase also. Among plants a similar approximation to a graduated scale of being is apparent. Referring to geological phenomena, he assumes that the primeval ocean invested our planet entirely, long after it became the habitation of living beings, and thus he was inclined to assert the priority of the types of marine animals to those of the terrestrial, and to fancy, for example, that the testacea of the ocean existed first, until some of them, by gradual evolution, were "improved" into those inhabiting the land. "Accordingly, in conformity to these views, inert matter was supposed to have been first endowed with life; until, in the course of ages, sensation was superadded to mere vitality; sight, hearing, and the other senses were afterwards required; and then instinct and the mental faculties, until finally, by virtue of the tendency of things to *progressive improvement*, the irrational was developed into the rational;"—in short, the ape became a man! This hypothesis of the transmutation of species is clearly stated and ably exposed in the second volume of Lyell's Principles of Geology. Adverting to the almost entire absence of the remains of mammiferous quadrupeds in the more ancient formations, and particularly to the absence of all traces of "creation's lord," this delightful author adds,—"The recent origin of man, and the absence of all signs of any rational being holding an analogous relation to former states of the animate world, affords one and the only reasonable argument in support of the hypothesis of a progressive scheme, but none whatever in favour of the fancied evolution of one species out of another."

* D'Aubisson, tom. i., p. 369.

tiously on the question of those deluges and revolutions of nature, which some of the German scholars of this great master have so boldly called to their aid in the solution of the difficulties they met with.

The indefinite antiquity of the *matter* of our globe has not only been contended for by geologists:—divines themselves have leaned to a similar opinion, as being not inconsistent with the Mosaic record: of this sentiment was the present Bishop of Chester.* M. Elie de Beaumont, a celebrated French geologist, supposes "that in the history of the earth there have been long periods of comparative repose, during which the deposition of sedimentary matter has gone on in regular continuity; and there have also been short periods of paroxysmal violence during which that continuity was broken." The circumstances of some of these movements are hinted at; among the rest, "the instantaneous upheaving of great mountain masses, which would cause a violent agitation in the waters of the sea; and the rise of the Andes may, perhaps, have produced that transient deluge which is noticed among the traditions of so many nations." This hypothesis of successive revolutions, or "Geognostic epochs," as they are termed by Brongniart, is ably examined by Mr. Lyell, whose opinion is in

* "According to that [the Mosaic] history, we are bound to admit that only one general destruction or revolution of the globe has taken place, since the period of that creation which Moses records, and of which Adam and Eve were the first inhabitants. The certainty of one event of that kind would appear from the discoveries of geologers, even if it were not declared by the sacred historian. But we are not called upon to deny the possible existence of previous worlds, from the wreck of which our globe was organised, and the ruins of which are now furnishing matter to our curiosity. The belief of their existence is indeed consistent with rational probability, and somewhat confirmed by the discoveries of astronomers as to the plurality of worlds."—*Sumner's Records of the Creation*, vol. i., p. 342. 4th Edition. 1825.

favour of the novel theory which accounts for all geological phenomena on the principle of a reiterated recurrence of minor convulsions, similar to those which still occasionally take place,* and their having acted through an inconceivably long period of time. Either of these schemes calls upon us for too implicit a credence in the exclusion of reasonable causes and recorded events. In reference to the latter theory, Mr. Conybeare justly remarks, that "historical records, and the very nature and physical possibilities of the case, alike compel us to dissent entirely from those crude and hasty speculations which would assign to the causes now in action, the power of producing any very material change in the face of things; and which would refer to these alone, acting under their present conditions, and with only their present forces, the mighty operations which have formed and modified our continents."†

In reference to Cuvier's theory of a succession of deluges, and after admitting that many of the phenomena of diluvial action taking place before our eyes may seem to favour such a notion, Mr. Jameson remarks, "What has just been said does not entitle us to admit that the various parts of the earth have been from time to time overflowed with water. Yet

* To those who happen not to have seen Mr. Lyell's able work, it may be proper to mention, that, while it is what it professes to be—"an attempt to explain the former changes of the earth's surface, by reference to causes now in operation," in opposition to the assumption of a series of convulsive cataclysms, it, at the same time, challenges for the various changes adverted to, what will probably be as reluctantly conceded—"an infinitesimal period;" in other words, the author attempts to prove, "that the minor volcanoes on the flanks of Etna may, some of them, be more than 10,000 years old," and quotes with respect the opinion of a distinguished botanist, "that some living specimens of the Baobab tree of Africa, and the Taxodium of Mexico, may be 5,000 years old."

† Geol. Eng. and Wales, p. xxxiii.

are there other appearances which completely indicate such a change, namely, beds of coal, and the fossil remains of land animals. The carbonisation of roots of trees in clefts of rocks, and of marsh plants in peat-bogs, which takes place, as it were, under our own immediate observation; the transitions of bituminous wood into pitch-coal, the frequent presence of vegetables partly converted into coal, in the neighbourhood of beds of coal, and which are more abundant the nearer they are to these beds; and, finally, the chemical nature of coal, which is similar to that of vegetables, go to prove the vegetable origin of the older and independent coal formation.

"Though some fossil vegetables might derive their origin, by being floated to quarters more or less remote from their native soil, as we find to be the case in many islands of the South Seas, and on other shores; on the other hand, neither the breadth and extent of beds of coal, nor the erect position in which fossil trees and reed plants are not unfrequently found in their neighbourhood, coincide with such an explanation. The plants from which these beds were formed, once stood and grew in the place where they were buried; and from these remains we infer that they were entirely land plants, tree-ferns, *Lycopodia*, and other cryptogamia. It also appears undeniable, that the land, being once dry, was, during a longer or shorter time, covered with luxuriant vegetation; that it was afterwards overflowed with water, and then became dry land again. But was this overflow of water produced by a sudden, violent, and universal catastrophe, such as we consider the deluge? Many circumstances leave room for opposite conjecture. If it is probable that the older or black coal is of vege-

table origin, the plants from which it has originated, must have suffered an incomparably greater change than those of more recent formations. Their composition and their texture, afford evidence of a long operation of the fluid in which the changes were produced; and their situation proves that the substance of the plants, though not entirely dissolved, was yet much comminuted, and was kept floating and swimming, and then precipitated. How can we, in any other way, account for the layers of sand-stone and slate clay, with which coal regularly alternates, so that from one to sixty alternate beds have been enumerated? How can we explain the combination of mineral coal with slate clay, or account for the appearance of bituminous shale, flinty slate, of iron pyrites and iron-ore, in the midst of mineral coal itself? We do not, however, admit of a repeated uncovering and covering of the land with water, and of a renewal of vegetation for every particular bed of coal; far from it, for violent inundations exhibit very different phenomena. These formations, like pure mineral formations, bear the evident impress of a lengthened operation, and of gentle precipitations; and whoever still entertains doubts regarding this, may have them completely removed by the condition in which vegetable remains are frequently found in the coal formations, by the perfect preservation of the most delicately shaped fern leaves, by the upright position of stems, and by other appearances of a similar character. It is also an important objection against the universality of the covering of water, notwithstanding the wide extent of beds of coal, that they are sometimes accompanied with fossil remains of fresh water shells, from which we are entitled to draw the conclusion, that

they must have been deposited in enclosed basins of inland waters. From the beds of coal found in various situations among *Alpine* limestone, as well as in other secondary formations, under similar circumstances, we are at liberty to maintain that they are not indebted for their origin to any universal and sudden revolution.*

"When we proceed to the second division of coal formations, to brown coal, or to *lignite*, the principal difference we discover is, that the change which the vegetables have undergone, having taken place at a time when the chemical power had lost much of its energy, was incomplete; and besides, we observe in the different brown coal formations, the same repetition of single beds alternating with other beds of rocks, the mixture of different minerals, and not unfrequently of upright stems. Some appear to be derived from sea plants, and others from fresh-water plants; but the greater proportion from land plants, They, equally with the beds of black coal, give evidence of a new overflow of water, and the water plants themselves, which never thrive at a great depth, and which frequently appear under prodigious beds of rocks, must have experienced such a change. But that change was scarcely of the kind which we understand by a deluge, and the frequent repetition of

* Mr. Greenhough, in an address, delivered in 1834, before the Geological Society, of which he was President, avows his concurrence with the theory of Mr. Lyell, first, perhaps, promulgated by Dr. Fleming in 1825, which assumes the impossibility of detecting any irrefragable traces of what is usually termed "Noah's flood," and to which other geologists attribute so many striking phenomena. "The vast mass of evidence which he [Mr. Lyell] had brought together, in illustration of what may be called *Diurnal Geology*, convinces me, that if, five thousand years ago, a deluge did sweep over the entire globe, its traces can no longer be distinguished from more modern and local disturbances."

deluges, indicated, according to some, by the repeated beds of coal from the transition to the newest tertiary periods, is hardly credible. It may be maintained, with more certainty, of *brown coal* than of *black coal*, that they have been formed in land water, and hence, in limited and isolated basins, since fresh-water animals are their constant attendants."*

Thus far the opinions of the Scottish philosopher, whose authority on such a question is entitled to respectful consideration. Another writer, however, whose ingenious lucubrations have recently been given to the world in two pleasing volumes, boldly joins issue with the impugners of the common theory, and at once announces that the scriptural cosmogony as literally interpreted, and the phenomena of geology as actually developed, are precisely accordant and synchronical. "By the sure guidance of the Sacred Record," says Granville Penn,† "which satisfies every condition that actual observation can demand, we are able to deduce to their *true chronological order* the various effects or phenomena, which the mineral geology arranges confusedly and anachronically, through neglect of the historical rule; arbitrarily and fancifully creating *facts and dates*, by *gratuitously multiplying* revolutions. For, let us examine, what general phenomena the mineral formations of the earth present, which may not be philosophically referred to one or other of the *four* obvious divisions of the Mosaical geology, *creative*, *fragmentary*, *sedimentary*, and *diluvial;* which are correspondently adumbrated,

* Cuvier's Essay on the Theory of the Earth. p. 425. Appendix by Jameson.

† A Comparative Estimate of the Mineral and Mosaical Geologies. Vol. II. p. 69.

but obscurely, and without any knowledge of causes, in the *primitive, intermediary, secondary,* and *tertiary* of the Mineral geology; viz. 1. to the first *formation* or *creation* of the substance and general frame-work of the globe: or, 2. to the *first revolution,* which formed the *basin of the primitive sea:* or, 3. to the *long period that succeeded,* during which that sea was stationary in its *primitive basin:* or, 4. and lastly, to the *second and last revolution,* in which the sea was *transfused* into a *new basin,* leaving the 'wreck and ruin,' of its *former basin* to constitute our *present continents.** To the first of these," continues Mr. Penn, "are plainly to be referred the *sensible characters* and *diversities* of all *primitive formations,* recognisable in the vast *frame-work* of the globe. To the *second,* are to be referred the universal characters of dislocation and subversion, of downfal and ruin, of fracture and dispersion of those *formations;* of subsidences, in primordial valleys and plains; of primitive

* Philosophers have not been less puzzled in attempts to produce, to their satisfaction, the Noachian deluge, than geologists have been in their endeavours to explain phenomena plainly indicative of diluvial action. Burnet, brought the waters from below, through the broken *crust* with which he fancied they had been covered during the Ante-diluvian period, and with fragments of this crust he formed the mountains. Woodward suspended, for a time, all *cohesion* among the particles of earth, and reduced the globe to a soft paste; while Whiston, not inferior in fancy to any of his predecessors, called a *comet* to his aid. Whatever may be thought of theories which assume a succession of cataclysms, or of those which, like that detailed in the text, make the most of a single revolution, certainly the hypothesis apparently the most strange, is that which denies that we have a right to expect to find any traces at all of the deluge of the Scriptures in post-diluvian times! Yet such was the opinion put forth by Dr. Fleming, in an interesting article published in the Edinburgh Philosophical Journal for 1825-26: he contends that "the flood exhibited no violent impetuosity;" hence he adds "with this conviction in my mind, I am not prepared to witness *in nature* any remaining marks of the catastrophe, and," he proceeds, "I feel my respect for the authority of revelation heightened, when I see on the present surface no memorials of the event."

volcanic eruption, fusion and transmutation: all which characters, mark the *first period of change* from the *first perfect condition* of the mineral sphere. To the *third* are plainly to be referred, the *triturated* character of all the fractured parts of those formations; the *sedimentary deposits* of their comminuted particles, and the incorporation of the *most ancient* of these into their *fragmentary base;* the accumulation of the questionable matter now constituting *coal*, and occupying generally this particular stage in the series of formations; the many volcanoes now *extinct*, whose vestiges are found on the *lower levels* of the earth, and in *mediterraneous regions*, remote from the sea, and which are *therefore extinct*, because their former activity resulted from a *communication with the waters which have been removed from them:* to this long *interval* are also to be referred, the incredibly numerous assemblages of *marine substances* in compact soils, at levels far above the surface of the present ocean; the *failures of the shattered base*, which have rendered *inclined*, and even *vertical*, so many of the *earliest horizontal depositions;* and, lastly, the subsequent accumulation of the latest and actual *horizontal strata* above those. To the *fourth and last* of these periods are to be referred, with equal evidence, the excavation of *valleys of denudation in secondary* or *sedimentary* soils, leaving the lateral parts undisturbed; the transport and aggeration of marine mineral masses; the moulding of the superior soils on their irregular substrata, displaying the evidence of *watery action* as plainly, as a stuccoed surface displays evidence of the action of an artist's trowel; the exposure, exsiccation, and induration of those masses now constituting the *secondary order* of *mountains, hills,* and

rocks; also various peculiarities of form and disposition, caused, from *local circumstances,* by the mass of waters in the progress of their retreat; the superficial *detritus,* and *colluvia of the sea-basin* spread over all these; and finally, the confused mixture of *organic terrestrial fragments,* animal and vegetable, previously constituting a part of the furniture of the *perished earth,* which are every where found in soils into which they were precipitated, *whilst those soils formed the soft and yielding bottom of the retiring sea.*"

Such, in brief, is the theory which, taking into account the discoveries of geologists, Mr. Penn, in his two interesting volumes, expounds in harmony with the sacred cosmogony.* The following passage in still fewer words, derived from Cuvier, will give a general idea of the system of Werner, the most celebrated among the continental geologists:—A universal and tranquil ocean deposits, in great masses, the primitive rocks,—those rocks which are distinctly chrystallized, and in which silica is the first predominating ingredient. Granite forms the base on which all others rest. To granite succeeds gneiss, which is

* Mr. Fairholme, in his work, entitled "A General View of the Geology of Scripture," agrees in the main with Mr. Penn. The basis of Mr. Fairholme's theory is, that "all the present dry lands of the earth were formerly the bed of the antediluvian sea;" and accordingly, that what are now the receptacles of coal strata, whether composed of sandstone or calcareous matter, have originally formed valleys or basins in the bed of the antediluvian sea, having received their contents while that sea was depositing the whole moveable matter of former continents, with which its waters must have been charged. In these deposits, large trees are sometimes found "detached from the great strata of coal, and extending from one stratum through a variety of others, which is sufficient proof," says Mr. Fairholme, "of these strata, at least, having all been formed at *one period.*" In the assumed diluvial origin of our coal basins, it is contended that the great chalk formation formed at least one portion of the bed of the sea at the destructive period, and yet in the usually received opinions of geology, the chalk is placed far above the coal.

only a granite beginning to be slaty. By degrees, mica predominates. Slates of different kinds appear; but in proportion as the purity of the precipitation is changed, the distinctness of the chrystalline grain is diminished. Serpentines, porphyries, and traps succeed, in which this grain is still less distinct, although the siliceous nature of these rocks evinces the returning purity ot the deposition. Intestine agitations in the fluid destroy a part of these primary deposites: new rocks are formed from their debris united by a cement. It is amidst these convulsions that living nature arises. Carbon, the first of these products, begins to shew itself. *Coal, a mineral formed from vegetables,* appears in vast quantities. Lime, which had already been associated with the primitive rocks, becomes more and more abundant. Rich collections of sea-salt, to be one day explored by man, fill immense cavities. The waters, again tranquillized, but having their contents *changed,* deposit beds less thick, and of greater variety, in which the *remains of living bodies are successively accumulated, in an order not less fixed than that of the rocks which contain them.* Finally, the last retreat of the waters diffuses over the land immense collections of alluvial matters, the first seats of vegetation, of cultivation, and of social life. The rents in the strata formed during these convulsions become filled with the rocks of various kinds, as granite, trap, &c., thus forming *veins* or *dykes.* The metals, like the rocks, have had their epochs and their successions. The last of the primitive, and the first of the secondary rocks, have received them in abundance. They become rare in countries of later formation. Commonly they are found in particular situations, in those *veins which seem to be*

rents produced in the great rocky masses, and which have been filled after their formation. But they are not all of equal age. Those which have been last formed are easily known, because their veins intersect those of the more ancient, and are not themselves intersected. Tin is the oldest of them all; silver and copper are the latest formed. Gold and iron, those two masters of the world, seem to have been deposited in the bowels of the earth, at all the different epochs of its formation; but iron appears at each epoch under different forms, and we can assign the age of its different ores.

It can scarcely be necessary to remind the least attentive reader, any more than the most superficial observer, that the masses composing the crust of the earth are by no means found in regular concentric depositions, stratum-super-stratum, like the coats of an onion: on the contrary, they are found, as we shall afterwards more particularly notice, singularly dislocated and intermixed; the beds placed at every angle with the horizon, from a parallel to a vertical position: the lowest, or most ancient deposites being in some instances elevated above the newest alluvial soil, as in the case of Dartmoor, in Devonshire; many parts of Cornwall; the well-known granitic mass of Mount Sorrel, in Leicestershire; and the Grampians of Scotland.

The following tabular series, proposed by Conybeare and Phillips, as divided into five comprehensive classes, will exhibit at one view the general succession of strata, and the principle of the Wernerian arrangement: the names in the second column are proposed by these gentlemen:—

Character.	*Modern Names.*	*Wernerian Names.*	*Former Names.*
1. Formations (chiefly of sand and clay) above the chalk.	Superior Order.	Newest Flœtz Class.	Tertiary Class.
2. Comprising— *a.* Chalk. *b.* Sands and clays beneath the chalk. *c.* Calcareous freestones (oolites) and argillaceous beds. *d.* New red sandstone, conglomerate and magnesian limestone.	Supermedial Order.	Flœtz Class.	Secondary Class.
3. Carboniferous Rocks, comprising— *a.* Coal measures. *b.* Carboniferous limestone. *c.* Old red sandstone.	Medial Order.	Sometimes referred to the preceding—sometimes to the succeeding class, by writers of these schools; very often the coal measures are referred to the former—the subjacent limestone and sandstone to the latter.	
4. Roofing slate, &c. &c.	Submedial Order.	Transition Class.	Intermediate Class.
5. Mica slate. Gneiss. Granite, &c.	Inferior Order.	Primitive Class.	Primitive Class.

In all these formations, from the lowest to the highest, we find a repetition of rocks and beds of similar chemical composition, i. e. siliceous, argillaceous, and calcareous, but with considerable difference in texture; those in the lowest formations being compact and often crystalline, while those in the highest and most recent are loose and earthy. Although the five comprehensive classes foregoing, will serve to exhibit a general view of the great outlines of Modern Geology, we no sooner begin to trace in detail the succession of mineral beds, than their numbers and variety appear to be endless, and but for some classification would be infinitely perplexing to the student. But by grouping together individual strata in a natural and easy manner, we reduce them to a limited number of series, each series comprehending nume-

rous individual strata naturally allied and associated together. To explain this by an example: if Derbyshire be the country under examination, the investigator will find a series of twenty or more alternations of beds of coal, sandstone, and slaty clay, repeated over and over; and beneath these beds a like alternation of limestone strata, with beds of the rock called toadstone. Here, then, all the individual beds at once resolve themselves into two comprehensive series—the upper containing coal, the lower limestone; each series being characterised by the repetition of its own peculiar members: such series are called Formations.* In some parts of the great northern coalfield, the workable seams, which as to the mass of them are spoken of as above the encrinal limestone, are sometimes interstratified therewith: at the same time, in certain other situations, the regular coal measures extend, as we shall afterwards find, under the magnesian limestone: where this is the case, some of the seams appear to have suffered deterioration. Extensive collieries, however, are established upon, and shafts sunk through the limestone, in places where it is fifty yards in thickness. The mining district of Alston Moor, &c., westward from Newcastle, consists of an immense floor of limestone, rich in veins of lead ore, and masses of which have occasionally been cut through in sinking the coalpits. It may be briefly added in this place, that the fossil substances more particularly alluded to in the present volume, as being more or less available for the purposes of fuel, may be enumerated in the descending

* Rev. W. D. Conybeare. Introduct. Geology of England and Wales. Part I., p. v.

order of the series as follow:—1. peat; 2. lignites; 3. bituminous coal; 4. anthracite. To each of these substances—or rather suits of substances, for each comprehends numerous varieties—modern science, as already intimated, attributes a vegetable origin; unless, indeed, we except the last—in which case, as we shall find, the exception will have to encounter strong evidence against its admission. The latter three bituminous fuels above named, seem to bear a striking relation in the gradual change which, in each case, the ligneous structure has undergone, to the geological newness or antiquity of the strata amidst which they commonly occur. The carboniferous group—or true coal measures, in which the vegetable origin of the beds, however undoubted, is by no means obvious, are comprehended, according to the preceding scale, in the medial order; above which, we have the lignites, where woody structure is very apparent, and sometimes but little changed; while below, even in the primary rocks themselves, we find anthracite, in which every trace of organic structure is commonly obliterated.* Nearly all the rocks lying above those termed primitive—more properly, primary—contain animal remains: the generally striking character and occasional profusion of these, give to the fossiliferous strata a peculiar interest, not only in the eyes of a student in natural philosophy, but to the casual observer: they are likewise of vast importance in aiding

* Professor Jameson considered what he calls "glance coal" and "black coal," to be original chemical deposits, "as little connected with vegetable remains, as the shells that occur in limestone are with that rock." His reasons were, that these coals occur in primitive rocks as gneiss, mica slate, clay slate, &c., and appear to be contemporaneous formations. More recent and extended investigation, however, does not seem to lend confirmation to such an opinion.

us in the identification of remote formations. The beautiful principle that every distinct geological deposit had its appropriate suite of fossils, was first promulgated by Mr. W. Smith, who may justly be styled the Father of Modern Geology. The formation of the Geological Society in 1807, the object of which was rather to collect and publish facts than to propound or support theories, has been vastly contributive to the diffusion of an interest in this study through the most intelligent classes of the community.

CHAPTER III.

PEAT.

Early use of Peat for Fuel—Its abundance in various countries—Hypothesis of the discovery of its inflammable nature—Notices of the knowledge and application of Peat in ancient times—Theories of the origin of Turf deposits—Various opinions and testimonials concerning the bituminization of Vegetable Matter—Plants which chiefly enter into the composition of Peat bogs—Irish and Scotch bog mosses—Extraneous remains found in Peat bogs—Analogy between the depositions of some stratified turbaries and the Coal formation—Method of digging and preparing Peat in Ireland—Varieties of Peat—Old practice of charring Turf—Popular prejudices in favour of Peat Fuel.

THE most common article of domestic firing in the less wooded districts of this country, previously to the general use of pit coal, was turf or peat, a species of fuel still dug and burnt in large quantities in those places where it abounds, and where wood or coal are scarce or unattainable. It would be difficult to say at what period the material now under consideration was first applied to its long-acknowledged

useful purpose: that it was used, as it is at present, from a very early period of our history, there can be no doubt: and, in the absence of ligneous and mineral fuels especially, its great abundance, easy obtainment, and singular production, arrest attention to one of those sources of comfort and convenience, which an infinitely wise Providence has opened in the store-house of Nature for the benefit of mankind. Peat claims some notice in a work like this, not only because that, in common with wood, it was an early, and still continues to be an article of extensive domestic consumption as fuel; but also, and more especially, because that, like coal, it may be regarded in some sort as a fossil, being dug out of the earth: it has even been considered, erroneously perhaps, to exhibit the progress of transformation from the living vegetable fibre to the compact lignite or jet: indeed, Mr. Williams, a respectable mineralogical writer, supposed that antediluvian peat bogs have been sources of fossil coal; an opinion which has not wanted the countenance of much higher authority.

It has been supposed that the discovery that various kinds of earth, or peat, might be used as fuel, would originate in accident in some place destitute of wood; as, not only may the heat of the sun, after long drought, occasion combustion,* but a spark, falling fortuitously on a turf moor, during a dry summer, often sets it on fire, and the conflagration it occasions generally lasts so long, that it cannot escape notice. Tacitus mentions a notable instance of

* Instances of this are not wanting in our day. The heat was so great during the autumn of 1833, that the ground in some places spontaneously took fire, especially in Switzerland: and in the summer of the present year (1834), a moor took fire owing to the long-continued drought, in Livonia.

this kind, which occurred in the neighbourhood of Cologne, not long after the foundation of that city. In Siberia, about the middle of the eighteenth century, a village, on account of its marshy situation, was removed to another place, and the remains, that they might be the more easily carried away, were set on fire. The flames having communicated to the soil, which was inflammable, occasioned great devastation; and when Gmelin was there, it had been burning for half a year.*

It seems, however, scarcely necessary to have recourse to such an hypothesis for suggesting the use of peat as an economical fuel; the presence and appearance of the substance itself, must at once have led to its application as a fuel by those who had previously witnessed vegetable matter of any kind in a state of combustion. Certainly, its value for this purpose was very early understood in Germany; for Pliny says expressly, that the Chauci pressed together with their hands a kind of mossy earth, which they dried by the wind rather than by the sun, and which they used not only for cooking their victuals, but also for warming their bodies.† The earliest certain account of turf in the middle ages, which Beckmann had met with, was a letter of sanction, by which an Abbot Ludolph, in the year 1113, permitted a nunnery near Utrecht to dig *cespites* for its own use, in a part of his *vena*. Now, there can be no doubt that *vena* signifies a turf-bog, and *cespite* turf. On the same authority, we are told that the words *turba, turbo, turbæ ad focum, turfa,* occur for turf in the years 1190, 1191, 1201, and 1210. The traffic in this kind

* Beckmann's Hist. Inventions. I. 335. † Hist. Nat. Lib. XVI. c. 1.

of fuel is recognised in the *Leges Burgorum* of Scotland, so early as about 1140. *Turbaria,* for a turf-moor, is found in Matthew Paris, who died in 1259; *turbagium,* in a diploma of Philip the Fair, in the year 1308, signifies the right of digging turf, as *turbare* does to dig up turf. Brito, who lived about 1223, is quoted as describing the productions of Flanders, as including *arida gleba foco siccus incisa marescis,* the latter words of which are understood to signify turf-bog. It may be added that *turbary,* or some cognate word, frequently occurs in the earlier foundation charters of the monasteries in this country, as conveying the right to dig turf generally within a certain limited extent of ground.

The natural history of peat has puzzled enquirers a good deal; and explanations of its origin, hardly less discordant than those recorded on the subject of fossil coal, have been entertained and defended. For intance, it was supposed by one author, to have had an origin coeval with the hills or the valleys in which it is formed;—by another, to have been a bituminous deposite of the sea;—by a third, the wreck of once-floating islands;—and by Pliny and others, to have had an entirely mineral origin. The fact that theories like these should have been taken up by modern writers, is the more remarkable, when it is recollected that peat-bogs, or mosses, not only lie so immediately commodious for inspection, as that their growth and transformation may be said to take place before our eyes; but, from the various animal and vegetable remains, and even works of art, which have been occasionally discovered embedded therein, their recent formation, as compared with the coal strata, is ren-

dered indisputable.* Dr. Anderson, as well as Dr. Plott, entertained the opinion that peat, as we find it in its natural state, is of itself a vegetable production, not a congeries of dead plants preserved by some mystical influence, as had been generally supposed, but actually alive, and in the highest degree of perfection of which it ever is susceptible. In its analysis, recent qualities, decomposition, and final decay, every circumstance, in the opinion of Dr. Anderson, tends to point it out as a recent vegetable substance, possessing certain properties of fresh vegetables, particularly that of inflammability, in a high degree of perfection. Its *appearance*, he admits, is indeed very unlike to those vegetable substances we have been used to observe, and more nearly resembles a mass of putrid vegetable matters than a real living substance.†

Mr. Parkinson objects altogether to the notion of deriving our peat-bogs from the germination and increment of a peculiar kind of moss. "Did peat," says he, "owe its formation to the supposed moss-plant, we should not expect to find it, as it often is

* The time required for the production of a given depth, has been a subject of frequent inquiry. In some cases, its growth has been so rapid as to be sensible to the observation of individuals, but, in general, it has been necessary to have recourse to evidence founded on circumstances involving a much longer period than human life. It has been remarked on the continent of Europe, that cavities of seven feet in depth have been filled with it in the short space of thirty years. And peat mosses have formed over certain fallen forests in Scotland, within fifty or sixty years: but we are not told to what thickness. Roman roads, utensils, and coins, have been found buried seven feet under mosses in this country: and only a few years ago, the palings of a park, described by Camden, were discovered beneath Chat Moss, in Lancashire.—*Vide an elaborate article on Peat, by Dr. Mac Culloch, in Edin. Phil. Journal.* 1820. *vol. ii. p.* 40.

† In Holland, submarine peat is derived from fuci; and on parts of our own coast from *Zostera marina.—Lyell.*

found, almost entirely composed of other species of vegetable matter. Indeed, that which is here supposed to have originated in one particular mode of vegetation, appears to depend on a certain change which affects vegetable matter in general; but perhaps some parts of the vegetable creation more than others. Thus the *confervæ* and the mosses, and particularly the *sphagnum palustre*, appear to be vegetables which are peculiarly calculated to suffer a conversion into this kind of substance. The promptitude with which the species of plants just enumerated appear to submit to their change, and their disposition extensively to spread themselves, through every interstice of such peat-bogs as they have possessed themselves of, may perhaps account, in a great measure, for that augmentation of peat mosses, which the Doctor [Anderson] says can have happened in no other way than by its increase in the manner of growing vegetables from the time of its first generation to the present hour."*

To prove that this augmentation is not of *growing peat*, but of vegetable matters under the influence of the common laws of vegetation, and at the same time to point out more clearly what appeared to be the actual circumstance which seemed to corroborate Dr. Anderson's opinion, Mr. Parkinson adduces an account of the process as delivered by an eye-witness. Dr. King, in a paper presented many years ago to the Dublin Society, says, that "Ireland doth abound in moss more than, I believe, any kingdom, insomuch that it is very troublesome, being apt to spoil fruit trees and quicksets.—This moss is of divers kinds:

* Organic Remains, vol. i. p. 203.

that which grows in bogs is remarkable; your light spongy ground is nothing but a congeries of the threads of this moss, before it is sufficiently rotten, (and then the turf looks white, and is light). I have seen it in such quantities, and so tough, that the turf spades would not cut it: in the north of Ireland, they, by way of joke, call it *old wife's tow,* and curse her that buried it, when it hinders them in cutting the turf: it is not much unlike flax: the turf holes in time grow up with it again, and all the little gutters in bogs are generally filled with it." The process by which the substance of peat is formed from these vegetables, Parkinson considers as "a bituminous fermentation peculiar to vegetable matter placed in such situations, as not only exclude the external air, and secure the presence of moisture, but prevent the escape of the more volatile principles, and which terminates in the formation of those substances termed bituminous."

Fig. 1.

It is now well known that turf, in general, consists of a congeries of the roots and fibres of about forty different species of plants, chiefly mosses, amongst which the *Sphagnum Palustre* of Linnæus, (*S. Latifolium.* Eng. Bot.) represented in the margin (*fig.* 1.), largely predominates. In addition to heath and fern usually growing on

turf moors, we commonly meet with the *myrica gale*, or Dutch myrtle, and one or more species of cotton grass *(Eriophorum)*, with its beautiful white tuft.

Mr. Hunter, speaking of the turf moors on Hatfield Chace, comprising thousands of acres, from whence a great part of Yorkshire was for ages supplied with fuel, observes, that when the turf is removed, a natural mould is discovered, like that of the surrounding country; "and a native of these regions, who had often watched the labourers on the moors, avers that he has seen the land beneath the turf lying in rig and furrow; as if, before the turf collected upon it, it had been submitted to the higher operations of husbandry."*

In some parts of Aberdeenshire, Dr. Anderson informs us, there is found a certain kind of peat-moss, which when formed into peats in the common way, the latter are found to be more tender and brittle than usual, so as to break down during the process of drying, into irregular lumps called clods. When one of these clods is thrown into the fire, it soon kindles, and burns with a clear bright flame, much resembling that which would be produced by a lump of tallow or butter in the same circumstances: these are therefore called *creeshy*, i. e. *greasy* clods, though they discover no degree of unctuosity to the sight, smell, or feel. These lumps, which are not common, are used as we use chips of wood, for kindling or reviving the fire. Professor Jameson states, that in some of the peat mosses in Scotland, the curious substance called mineral tallow has been found; and as it is now known to chemists that the muscular parts of animals

* South Yorkshire, vol. i. p. 154.

after having been buried some time where water could have access to them, are changed into a fatty substance resembling spermaceti and called *adipocire*, it has been conjectured that the unctuosity of this peat and the mineral tallow are indebted for their existence to animals that have been buried in the bogs; in which situations indeed the more solid proofs of such occurrences are often found. Besides, it is now well known that many of these vast mosses occupy the sites of forests that have perished within the historic period—the causes which have led to this destruction are various: but in many places, besides the record or tradition of the fact, not only are prostrate trees, but upright rooted stems found abundantly embedded in the accumulated vegetable matter of the bog. Some of the largest trees known in this country, and well adapted for the masts and keels of vessels have been discovered in such situations. Mr. Hunter informs us that in the bogs about Hatfield, "firs have been found thirty yards in length, and oaks twenty-five and thirty-five yards: trees of other species are found, as the ash, birch, yew, and willow; but the fir is the most abundant: large quantities of fir cones and hazel nuts are discovered."

One of the most interesting facts in the history of peat, is its containing powerful antiseptic properties, by which animal substances are preserved entire for a great number of years. Many such instances are on record. In June 1747, the body of a woman was found six feet deep in a peat-moor in the Isle of Axholm, in Lincolnshire. The antique sandals on her feet afforded evidence of her having been buried there for many ages; yet her nails, hair, and skin are described as having shown hardly any marks

of decay. A pair of sandals taken from the feet of a body so found in the time of Elizabeth, were long hung up in one of the churches in this country, as having belonged to an antediluvian. The vast antlers, and even the entire skeleton, of the gigantic elk *(cervus elephas,)* now extinct, sometimes occur in the Irish bogs; as do also the remains of man. In a turbary on the estate of the Earl of Moira, in Ireland, a human body was dug up, a foot deep in gravel, covered with eleven feet of moss; the body was completely clothed, and the garments seemed all to be made of hair. Before the use of wood was known in that country, the clothing of the inhabitants was made of hair, so that it would appear that this body had been buried in that early period; yet it was fresh and unimpaired. In the Philosophical Transactions we find an example recorded of the bodies of two persons having been buried in moist peat, in Derbyshire, in 1674, about a yard deep, which were examined twenty-eight years and nine months afterwards; "the colour of their skin was fair and natural, their flesh soft as that of persons newly dead."

If we could regard, as some have done, peat, jet, and coal as different stages of the same transmutation of organized matter, the present chapter would be entitled to its place in this volume, not only because it treats of the most obvious and ancient species of exhumated fuel, but also as exhibiting the actual commencement of the coal series. Mr. Conybeare, speaking of peat as an alluvial deposite, and as belonging to an order of causes still in action, thus describes the changes which he imagines it may undergo: "the upper parts of its mass present the fibres

of the vegetables whence it originates, and which still cover its surface (principally *sphagnum palustre*) in an almost unchanged state; in the middle part the texture is gradually obliterated, and the mass passes into a compact peat; in the lowest portion this change is carried still further, and substances very analagous to jet are found: in some instances beds of peat alternate with beds of mud or sand, or even shells and marle, deposited in lakes; or of silt and sand formed in the æstuaries of rivers; in these cases they appear exactly to represent an imperfect and unmatured coal-formation."* This analogy to the proper carboniferous strata, is still more strikingly exemplified by the well-known fact that some of these mosses contain metallic oxides in considerable quantity: bog iron-ore is not unknown to the smelter. It occurs in large rusty-looking masses, being deposited by the flowing of chalybeate water highly impregnated. Copper is likewise found in a similar state, particularly in the county of Cork, where the particles are so abundant that, in the year 1812, from a cupriferous peat-bog, on the east side of Glendore harbour, forty or fifty tons of the dried peat produced, when burnt, one ton of ashes, containing from ten to fifteen per cent of copper. But to advert for a moment to the passage above cited:—notwithstanding the assertion —not disputed as to the fact, that "substances analagous to jet are found" in the peat, and some allusion to the experiments of Dr. Mac Culloch, intended to shew that the agency of fire applied to beds of lignite and peat, may convert, not wood, but vegetable matter previously bituminized into coal, it does not

* Geology, &c. Part I. p. 328.

appear that Mr. Conybeare is fairly obnoxious to the following strong censure of a Continental writer quoted by Mr. Granville Penn :—" I shall not stop to examine the different opinions that have been propounded on the *origin of coal:* I shall only notice one, which is not without a specious appearance. It is by some supposed that the three great fossil combustibles, *coal, lignites,* and *peat,* pass from one into the other by an effect of successive elaboration, which is continually proceeding; so that, in the course of elaboration, our *peat-beds* would become *coal-beds.* This idea could only enter the mind of one who is ignorant that nature has fixed in the formation of these substances a line of demarkation which separates them irrevocably." * Mr. Penn, after quoting the foregoing passage, inquires, with reference to a theory presently to be noticed, whether lignites—bituminised fossil wood—may not have resulted from *terrestrial* vegetation, forests of the perished earth floated and sunk, during the great diluvial catastrophe, within those marine soils whose *native vegetation* is now transformed into coal? To this, it might be said in reply, that if all other conditions were found concurring in favour of the notion that our beds of bituminous coal have been deposited by the subsidence of vegetable matter floated from an immense distance by means of some diluvial catastrophe, there exist modern phenomena by no means unfavourable to such an hypothesis. At all events, vast depositions of lignite are constantly taking place from this cause in some northern latitudes. We are told, on good authority, that tropical plants are taken up by the great

* D'Aubuisson, tom. ii. p. 301.

current flowing out of the Gulf of Mexico, and carried in a northerly direction, till they reach the shores of Iceland and Spitzbergen uninjured, except in having commonly suffered complete decortication. "The banks of the Mackenzie river display," says Mr. Lyell,* "almost every where, horizontal beds of wood coal, alternating with bituminous clay, gravel, sand, and friable sandstone; sections, in short, of such deposits as are now evidently forming at the bottom of the lakes which it traverses. Notwithstanding the vast forests intercepted by the lakes, a still greater mass of drift wood is found where the Mackenzie reaches the sea, in a latitude where no wood grows at present, except a few stunted willows. At the mouths of the river, the alluvial water has formed a barrier of islands and shoals, where we may expect a great formation of coal at some distant period."

But to return to peat—it has seldom, if ever been discovered within the tropics, and it rarely occurs in the valleys even in the south of France or Spain. It abounds more and more in proportion as we advance farther from the equator, and becomes not only more frequent but more inflammable in northern latitudes.† The use of peat as an economical fuel, is, as already mentioned, very general in those parts of the United Kingdom where it abounds—but more particularly in Scotland and Ireland,—one-tenth of the latter being reckoned to be covered with bog matter. Where it exists plentifully in England, it is sometimes burnt, either in admixture with coal itself, or as a cheaper substitute; and so far is it from being altogether excluded in those counties most noted for coal, that even

* Geology, ii. 249. † Rev. Dr. Rennie on Peat, p. 260.

in Northumberland as well as Yorkshire considerable quantities of peat firing are expended.

It is scarcely possible to pass—in the Summer season especially, through those parts of Ireland which are remote from the capital and the larger towns, without witnessing somewhere or other, the operations of the turf-diggers. The turf-spade, in shape is not unlike that used by gardeners in general; but is lighter and narrower. With this implement, the workman first cuts away, in a sort of large cubical sods, the superior turfy stratum of the bog: as this is comparatively loose and light, it is presently dried and ready for use. On digging lower, the substance of the peat becomes more moist and compact, and appears more like rotten wood than the roots of moss; it has, however, a sufficient degree of fibrous connexion to admit of its being readily raised in masses somewhat resembling large bricks. These quadrangular clods, which the digger cuts out and throws up with great dexterity, are heaped in small stacks to dry; after which, they are either used on the spot, or carted away by purchasers, according to circumstances —to preserve them through the Winter, the piles are sometimes thatched. On sinking still lower in the bog, the matter becomes less solid, loses its coherency, and assumes the consistency of black sludge; this is laded out with a scoop, similar to that used by brickmakers for wetting their clay, and is thrown upon a smooth floor or bottom, where, from exposure to the air, it stiffens and consolidates; it is then cut and cross-cut with the spade into cubic masses which, on becoming dry, are found to burn with great freedom, in consequence of the bituminous saturation, to which the matter of them seems to have been subjected.

The accumulations of peat differ considerably in area, depth, and quality. On the banks of the Shannon, one of the moss tracts is stated to be about fifty miles in length, by two or three miles in breadth. In mountainous situations the depth of the bed is seldom above three feet—rarely so much: in bogs and low grounds, into which alluvial peat is "drifted," it is sometimes found forty feet thick—though fully one-half of this volume is water.* The quality of peat varies according to the different situations where it is formed; as those places differ in drainage; in the nature of the vegetables they produce; and in the kind and quantity of alluvium deposited among the dead vegetable matter. The conditions of purity, compactness and weight, are required in those kinds which have been sometimes estimated as equal to inferior coals. Dr. Mac Culloch † considers peat as presenting five obvious varieties, depending upon situation, viz.,—mountain peat, marsh peat, lake peat, forest peat, and marine peat: he likewise gives lists of such bog and other plants as he conceives enter most largely into the composition of each kind. As a fuel, however, Mr. Tredgold‡ appears to consider it sufficient to divide peat into two kinds only—the first, that which is compact and heavy, of a brownish black colour, and with scarcely any vestiges of its vegetable origin

* Inundations of fluid peat have occasionally taken place to a considerable extent. In most of the instances recorded, the bogs have become so saturated with moisture, that, lying aslope above some subjacent level, they have slid or flowed down. A notable instance of this sort was the irruption of a part of the Solway Moss, which at the time [1772] consisted of 1300 acres very deep and tender: a part of this mass, on being deluged with rain, flowed from its ancient bed, and covered 300 acres of the adjoining land, to a depth of 30 feet.—*Phil. Trans. vol. xiii. p.* 305. *Abridgment.*

† Edin. Phil. Journal. Vol. ii. p. 40.

‡ Tredgold on Warm. and Vent. Buildings, p. 44.

remaining; this is the best kind:—the second is light and spongy, of a brown colour, and seems to be a mass of dead plants and roots which have undergone little change; it inflames readily and is quickly consumed. It must be remarked, however, that so highly imflammable are some even of the denser kinds, that the characteristic distinctions of bituminised wood are considered insufficient to explain the circumstance—and hence, the Ince peat of Lancashire is believed to be penetrated by petroleum derived from some bituminous spring. According to the authority above named, the weight of a cubic foot of peat, varies from 44lbs. to 70lbs.; the denser variety affording about 40 per cent. of charcoal. Sir H. Davy has stated that in general, one hundred parts of dry peat contain from 60 to 99 parts of matter destructible by fire, and the residuum consists of earths, usually of the same kinds as the substratum, as clay, marl, lime, &c.

The practice of charring turf obtained at an early period, especially in Germany where it was much used: it is said to have been employed in this state at the Freyberg smelting houses about the year 1560, though the undertaking, Beckmann assures us, was not attended with success. In some parts of Bohemia, Silesia, Upper Saxony and other places, as we learn from the same authority, it is common to subject the turf used in working metals, to a certain degree of combustion in kilns or furnaces; after undergoing this process, it is considered that it kindles sooner, burns with less air, and forms a more moderate and uniform fire. Attempts to substitute peat treated as above, for charcoal in some of the smelting establishments of this country, were not unknown during the earlier part of the seventeenth century. And at this

day, a description of peat called in some parts of Devonshire "Blackwood," is, when cut, dried and charred, used by the smiths in tempering edge-tools.

"Turf," says an Irish writer, Dr. King,* "is accounted a tolerably sweet fire; and having very impolitically destroyed our wood, and not as yet found stone coal, except in a few places, we could hardly live without some bogs; when the turf is charred, it serves to work iron, and even to make it in a bloomery or ironwork; turf charred, I reckon the sweetest and wholesomest fire that can be; fitter for a chamber, and for consumptive people, than either wood, stone coal, or charcoal." Notwithstanding this truly Irish eulogy of the national bog fuel, one of the strongest objections to the use of peat for domestic fires is the disagreeable odour it emits while burning. But in this, as in many other instances, we are reminded of the adage *de gustibus nil disputandum;* for Mr. Loudon, in his interesting Encyclopædia of Cottage, Farm, and Villa Architecture, mentions that, in most parts of the Highlands of Scotland, peat fuel is so abundant, and the people so attached to peat smoke, that when new houses, built with stone and lime, with chimneys to carry off the smoke, were introduced on the Marquis of Stafford's estates, many of the farmers refused to live in them; and it took years, before others could be reconciled to the clean and cold appearance which they alleged was produced by the want of smoke.

* Phil. Trans. Vol. xv. Abridgment. 1685.

CHAPTER IV.

NATURAL HISTORY OF COAL.

Nature and origin of Coal—Different opinions which have been entertained on that subject—Hypothetical queries answered—Inferences and illustrations of the vegetable origin of Coal—Chemical investigations of Mr. Hatchett—Three conditions of Fossil Fuel; submerged forests, lignites or bituminized wood, and true Coal—Description of the Bovey Coal formation—Supposed state of the atmosphere at the period when the Coal Vegetables flourished—Remarks on the prodigious supply of materials—Forests and drift wood—Have the vegetable matters forming the Coal strata been floated from a distance, or did they originally grow in situations near to those places where, in their changed condition, they are now found?—Causes which may have operated in effecting the bituminization of the Coal plants—Opinions of Mr. Penn and others—Supposed peaty origin of Coal—Anthracite.

OF the formations or suites of strata already briefly described towards the close of Chapter II., that containing the carbonaceous deposits is the most interesting: its age and composition, involve problems

which engage the researches and excite the speculations, not of the mineral geologist only, but also of persons addicted to the study of pure mineralogy and chemistry. Numerous treatises have at different times been devoted directly or incidentally to disquisitions upon the nature and origin of coal; and, as might be expected, the most conflicting and even contradictory conclusions have been come to on the subject. Mr. Hatchett,* enumerates as follows, the different opinions which have been propounded with respect to the origin of this substance—of these, Mr. Penn says, "the first three are chemical and scientific; the fourth is altogether speculative and imaginary, and pertains exclusively to the mineral geology":—

I. That pit-coal is an earth or stone chiefly of the argillaceous genus, penetrated and impregnated with bitumen. But Mr. Kirwan long ago, very justly remarked, that the insufficiency of this solution is demonstrated by Kilkenny and other coals, which are devoid of bitumen, and also that the quantity of earthy or stony matter in the most bituminous coals bears no proportion to them.

II. The most prevailing opinion is, that mineral coal is of vegetable origin: that the vegetable bodies have, subsequently to their being buried under vast strata of earth, been mineralized by some unknown process, of which sulphuric acid has probably been the principal agent, and that by means of this acid, the oils of the different species of wood have been converted into bitumen, and a coaly substance has been formed.

III. The opinion of Arduino is most singular: he

* Philosophical Transactions, 1806.

conceives coal to be entirely of marine formation, and to have originated from the fat and unctuous matter of the numerous tribes of animals that once inhabited the ocean.

IV. Mr. Kirwan considered coal and bitumen to have been derived from, what he designates, "the primordial chaotic fluid."

Could we imagine a person, acquainted with the methods of modern physical investigation, to hear the enquiry relative to the vegetable origin of our coal fields started for the first time, it may be supposed he would naturally think of propounding a series of questions something like the following :—

1. Is coal, when subjected to chemical analysis, found to yield products analagous to those derived by similar processes from ligneous matters ?

2. Have any experiments been instituted by which the conversion of wood into matter resembling coal has been effected ?

3. Do there any where exist in situ, masses of matter exhibiting on a large scale, the actual stages or progress of such a transmutation as that assumed by geologists—i. e. depositions presenting the distinct transition characteristics, comprehending undoubted woody fibre in the superior, or upper or newer beds, and of true mineral coal in the inferior or lower, or more ancient strata ?

4. Do the coal strata present any organic remains or other phenomena indicative of vegetable origin ?

To every one of these queries a distinct answer in the affirmative might be given; nevertheless, the enquiry developes collaterally so many anomalous phenomena, that the application of facts tending to establish a conclusion at which Mr. Hatchett, and

recent geological writers in general have arrived; namely—that the theory which regards vegetable substances as the principal origin of coal, much the most probable, because it is corroborated by the greater number of geological facts, as well as by many experimental results,—has by no means been unincumbered with difficulties. It has, indeed, been justly remarked, that until lately the vegetable origin of coal has, in the more perfectly fossilised varieties, been rather inferred than demonstrated. Peat, we know, from actual observation, to consist of decayed vegetables. The process is going on under our eyes: we can watch its progress, distinguish its degrees, and observe its results. The lignites of the upper deposits are so analagous to peat, and so decidedly present traces of woody tissue, that we can have no reasonable doubts respecting their origin. Bovey coal is evidently dicotyledonous wood partially altered. In the coal beds of the lower formations, however, we cease to recognise decided appearances of vegetable matter, and in several varieties the texture is so compact or crystalline, that were analogy inapplicable, they could not be considered as organic. This is more especially the case with glance coal, as also with the variety called pitch coal. The foregoing are the sentiments of Mr. Witham, who, in his work on Fossil Vegetables, has delineated beautiful sections of jet, lignites, and even the cannel coal of Lancashire, in all of which the traces of organization are decided—though some of these, as the Bovey coal for instance, where the woody character is strikingly obvious exteriorly, and in the grain viewed generally, did not present those interesting appearances under the microscope, which might have been expected.

Chemical investigation, already adverted to, although pursued by several able experimentalists, and in its results developing much curious illustration, has perhaps been the least conclusive in its bearings upon the question of the ligneous origin of mineral coal. Mr. Hatchett, however, not only obtained from coal a substance possessing properties analagous to those belonging to that extractive principle of several vegetables, especially oak bark, called tannin,—but likewise resin, a product which has always been attributed to organized bodies, particularly to those of the vegetable kingdom; and which does not appear to have been obtained from coal previously to the experiments of the above-named individual. Mr. Hatchett, in his various experiments, found it easy to produce, by means of chemical action upon vegetable substances, a matter analagous to Bovey coal, with the important exception that the artificial product was never bituminous; and it is stated, on this authority, that true bitumen has never been formed by any artificial process hitherto devised, either from the resins or other vegetable substances: products resembling it in odour when burned and in other properties, have been obtained —but the effects of alcohol or water always proved these products not to be bitumen. "But synthesis of natural products," observes Mr. Hatchett, "although required in strict chemical demonstration, is (as we have but too often occasion to know) seldom to be obtained, especially when operations are performed on bodies whose component parts are liable to an infinite series of variations in their proportions, qualities, and modes of combination. Considering, therefore," proceeds our authority, "that bitumen and resin afford by certain operations similar products; that resin and

bitumen are found blended together by nature, and that this mixed substance accompanies a species of coal which in many parts still exhibits its vegetable origin, whilst in others it passes into pit-coal, we may, with the greatest probability, conclude, that bitumen is a modification of the resinous and oily parts of vegetables, produced by some process of nature, which has operated by slow and gradual means on immense masses, so that even if we were acquainted with the process, we should scarcely be able to imitate its effects, from the want of time, and deficiency in the bulk of the materials. But although bitumen cannot at present be artificially formed from the resinous and other vegetable substances by any of the known chemical processes, yet there is every reason to believe, that the agent employed by nature in the formation of coal and bitumen has been either muriatic or sulphuric acid; and when it is considered that common salt is never found in coal mines, except when in the vicinity of salt springs, whilst on the contrary, pyrites, sulphate of iron, and alum, most commonly are present; these facts, together with the sulphureous odour emitted by most of the mineral coals when burned, appear strongly to evince the agency of the latter. That this has been the case, seems also to be corroborated by the great resemblance which the coals formed artificially from many vegetable substances bear to the mineral coals; especially as the similarity is not confined to external characters, but extends to other properties. It may be added that, by the action of sulphuric acid on vegetable bodies, a much greater portion of their carbon is converted into coal, than when the same are subjected to the effects of fire."

In further illustration of the now so generally ad-

mitted change of vegetable matter into coal, by whatever process, and in addition to what has been said in reference to peat, it will be found that our own island presents us with a tripartite series of fossil combustible substances, the intermediate member of which exhibits, in a striking manner, the coal in that stage of partial mineralization, which appears so conclusive in favour of the theory of a ligneous origin: as an illustration of the most recent deposition, or modern member of this threefold series, may be mentioned the submarine forest on the coast of Lincolnshire,* the timber of which has not suffered any very important change in its vegetable character. There are several other accumulations of wood in different parts of the kingdom—in some cases the remains of forests known to have been existing within the period embraced by our annals. Occasionally, the substratum of our immense peat depositions consists, as previously noticed, of vegetable remains of a much larger order than those forming the superior beds—trees of various descriptions, the species in many instances readily distinguishable, and affording by their exhumation, not only supplies of fuel, but even timber for various economical purposes. Striking examples of this latter circumstance are daily taking place in Holderness, a large triangular district, consisting chiefly of peat moors, and tracts formed by the sediment of ancient inundations, bounded on one side by the German Ocean, on another by the estuary of the Humber, and on the third by the chalk formation of the Yorkshire Wolds.† The other ex-

* Described by Correa de Serra, in Phil. Trans. 1799.

† John Phillips, in Phil. Mag. April, 1834. p. 283. Mr. De la Beche (Geological Manual, p. 166) gives a concise but interesting account of several of these ligneous accumulations, as noticed by various writers.

treme series of ligneous matter, and which has undergone the most entire change, comprises the varieties of pit-coal, so abundant in many parts of this country, and in which almost every appearance of vegetable origin has been destroyed. The formation apparently equally remote from the two extremes* just noticed, but which nevertheless discloses peculiarities singularly analagous to both of them, is brown coal, (the *braunkohlen* of German Mineralogists) found abundantly in some parts of the world. In this country it is represented by the well-known strata of bituminous wood, called Bovey coal, which exhibits a series of gradations from the most perfect ligneous texture, to a substance nearly approaching the characters of pit-coal, and, on that account locally distinguished by the name of stone coal. This fossil which is believed to have been deposited posterior to the chalk formation, and which is denominated from the place where it has long been found—Bovey-Tracey, near Chudleigh, in Devonshire—was first largely described by Dr. Milles in a letter to the Earl of Macclesfield, President of the Royal Society, 1760;† it was also

* Lignites, which are manifestly bituminized wood, hold an intermediate place in the gradation between vegetable matter and pit coal. They have the fibre of the former, with the jetty lustre and fracture of the latter. Some lignites closely resemble peats in their chemical characters; others seem to graduate into perfect coal. It is, therefore, the geological position in the coal measures that determines this combustible. Whatever is found in the strata above the magnesian limestone has been called a lignite coal, adds Dr. Ure, (Geology, p. 172,) from whom this passage is taken, is in fact to vegetable matter, what adipocire is to animal; the completion of the chemical change, in which the fibrous structure disappears. Lignite has generally *a woody aspect*; coal always that of a rock.

† Philosophical Transactions, vol. li., p. 535.—The Bovey coal has been worked about a century; and the whole area explored in that time may amount to nearly twelve acres. The coal is mostly used for steam engines and in the burning of lime, and occasionally in the manufacture of earthenware. It is not used at present for domestic purposes, its sulphureous exhalations being not only disagreeable, but noxious.

made the subject of a series of experiments by Mr. Hatchett, the details of which were laid before that illustrious body in 1804 and 1806, and from which details many of the particulars of the present treatise are taken. On comparing the two accounts, it is impossible not to be struck with the remarkable difference which the effect of the progress of science for about half a century, had in determining to such opposite conclusions, the opinions of two philosophical individuals, having the same substance before them. The object of Dr. Milles in his remarks was to establish the hypothesis, that this and similar substances are not of vegetable but of mineral origin; and to prove this, he adduces a great number of cases, most of which, however, in the present state of natural history and of chemistry, must be regarded as proving the contrary.

The Bovey coal is found in strata, corresponding, in almost every particular, with the fossil wood of Iceland, called surturbrand, described by Von Troil, Bergmann, and others. The different strata of both these substances are likewise similar, being composed of wood or trunks of trees, which have completely lost their cylindrical form, and are perfectly flattened, as if they had been subjected to an immense degree of pressure. The succession and thickness of the strata at Bovey are thus described by Mr. Parkinson:

	Ft.	in.
Stratum, No. 1...Thickness	1	0
2	0	18
3	2	0
4	18	0
5	2	0
6	0	9
7	0	4
8	1	0
9	1	0
10	1	9
Stratum, No. 11...Thickness	0	6
12	2	0
13	1	2
14	1	3
15 The great bed in 4 floors ...	2	0
	1	2
	1	4
	1	0
16 Little bed..	1	0
17 Last bed...	2	7

Fig. 2.

The annexed sketch *(fig. 2.)* taken from Parkinson, shews the arrangement of strata; the black parts, lettered A B C D and E, represent layers of coal corresponding with the foregoing Nos. 5 to 9 inclusive; the lined portions are strata of an inferior kind of coal, not worth taking up; and the white spaces indicate argillaceous strata—the uppermost of these, or that between the fifth and sixth bed of coal, being ten feet thick, including the two pseudo seams; and that between the sixth and seventh beds, also including two worthless strata, is eight feet thick. The lower coal strata furnish the best and strongest substance for burning. The shaft from the grass to the bottom of the last coal stratum, is seventy-five feet deep. It has been bored thirty-three feet still deeper, but nothing was discovered, except a muddy kind of clay, intermixed with sand. The disposition of the strata is displayed by their method of working: they begin at the top, and clear away to the distance of eight or ten fathoms, and work down, in a perpendicular direction, through the various strata to the bottom of the shaft: then recommence their operations.*

The direction of the strata at Bovey, is from north to south; the inclination or dip tending to the latter. This inclination was stated by Mr. Scammell, who furnished Parkinson with the particulars of this coal, to be about one foot in six: the leading part is from

* Organic Remains, vol. i., p. 124.

east to west: the northern part bassets, or comes to the surface, within an hundred yards of the shaft, where it is cut off by a bed of sand; to what depth the southern extremity reaches had not been, and probably cannot be ascertained: it has been found, however, to extend a quarter of a mile. The eastern portion extends more than seven miles, though the western has not been traced more than two miles. The whole deposit is said to occupy a kind of basin, or ancient valley.

This formation is by no means peculiar to Devonshire—nor even to Great Britain: strata of bituminous wood are found in various parts of France, in the vicinity of Cologne, in Hesse, Bohemia, Saxony, Italy, and especially in Iceland as already mentioned. The Bovey coal is commonly of a chocolate-brown, and sometimes almost black. The quality and texture are various in different strata: from some of these, it is obtained in the form of straight flat pieces three or four feet in length, resembling boards, and, therefore, called board-coal: thin pieces of this kind, when first dug, and while moist, will bend somewhat like horn; but as it dries it loses its elasticity, and becomes brittle. The sectile appearance in some specimens, cut and polished by Mr. Witham, is very beautiful, and comparatively regular. Others have an oblique, wavy, and undulating texture, and, as Dr. Milles observes, have a strong resemblance to the roots of trees, from which, most probably, this sort has, in a great measure, been formed. Some kinds, also, appear to be more or less intermixed with earth; but that which produces the most powerful and lasting fire, is called stone-coal; it is black, with a glossy fracture: has little or none of the vegetable texture;

is more solid and compact than the others, being almost as heavy as some of the pit-coals, the nature of which it seems nearly to approach. Mr. Hatchett submitted the wavy species of Bovey coal to chemical examination, and found that 200 grains by distillation yielded :—

	Grains.
1. Water, which soon came over acid, and afterwards turbid, by the mixture of some bitumen.........	60
2. Thick brown oily bitumen	21
3. Charcoal	90
4. Mixed gas, consisting of hydrogen, carbonated hydrogen, and carbonic acid, estimated at......	29
	200

The charcoal, by incineration, left about four grains of yellowish ashes, consisting of alumina, iron, and silica ; but it was remarkable that there was not the smallest trace of alkali. No extractive substance was derived on digesting the coal in boiling water : but by digestion in alcohol a tincture was formed, which, by evaporation, afforded a substance possessing all the properties of resin, and proving that the whole of the proximate principles of the original vegetable have not been entirely changed—a small portion of true resin, not converted into bitumen, (the ultimate effect of those causes which convert vegetable matter into coal,) still remains inherent in the mass.

The Bovey coal is not only bituminised to the degree intimated above, but there are indications of an excess of inflammable matters of this class ; Dr. Milles observes, that, "Amongst the clay, but adhering to the coal, are found lumps of a bright yellow loam, extremely light, and so saturated with petroleum, that they burn like sealing-wax, emitting a

very agreeable and aromatic scent." This substance, however, Mr. Hatchett has found not only to be of a composition remote from that suspected by Dr. Milles, but totally different from any of the bitumens hitherto discovered, consisting partly of resin, and partly of asphaltus, and hence it has been called Retinasphaltum.

One objection formerly urged against the vegetable origin of coal, as it partakes less of a chemical or even philosophical than of an historical character, becomes weak in proportion as our knowledge of the extent of causes formerly and actually in operation, is increased. Dr. Milles, in the Remarks already adverted to, in enumerating the reasons why he considers the Bovey coal to be not of a vegetable, but of a mineral origin, says, "In the first place, there does not seem to be any imaginable cause in nature, which could bring together such a mass of fossil wood, as is found in this, and other strata of the like kind in different parts of Europe. It extends here [at Bovey], to the depth of seventy feet: in that at Munden [in Germany], they have sunk fifty feet, without coming to the bottom." There are few persons at the present day, so unacquainted with the signal monuments of diluvial action on the different portions of the earth's surface, as to find any difficulty in conceiving that the same tremendous energy, whatever it may have been, which has collected vast mountains of marine exuviæ, would be abundantly adequate to bring together vegetable masses equal to any bituminous fossil strata in the known world. It is by no means necessary to imagine that they have been transported from any great distance, though that supposition would contain in it nothing improbable.

That there might be some peculiar conditions in the exuberance and chemical nature of primeval vegetation seems probable. M. Brongniart (in *Prodromus des Veget. Fossiles*, 1818.) was the first who, in explaining the carbonised nature of coal, thought it necessary to suppose that the atmosphere once contained a much larger proportion of carbonic acid gas than it does now. He assumes that as it might happen that there was then much less mould, plants must need have lived by absorbing, through the leaves, and appropriating to themselves, much carbon taken from the air. M. Th. de Saussure * has demonstrated, that a proportion of two, three, four, and even eight per cent. of carbonic acid gas in the air, may be favourable to vegetation. In this way the gigantic height of plants at an early period is thought to be explained: while the simultaneous existence of many reptiles and the absence of mammalia is deemed to accord with the hypothesis.†

* De Candolle. *Edin. Phil. Journ.* Jan. 1835.

† This theory is elegantly expounded by Mr. Burnet, Professor of Botany in King's College, London, as follows:—"The office of ferns and the other plants of the coal formation, and the final cause of their predominance in that period, would seem from numerous facts to be, that by their assimilation of the carbon, and liberation of the oxygen with which it was combined, they might purify the atmosphere, and bring it into a condition in which it would become respirable by reptiles, beasts and man. That such was the primitive condition of the atmosphere, and that it was thus gradually purified by the growth of plants, seems to be not improbable, from the circumstance that reptiles and other cold blooded animals, which can endure and enjoy an atmosphere that would be fatal to warm blooded animals and man, are the earliest of which any fossil remains are found. That the atmosphere at first was very geatly loaded with carbonic acid, is probable from reptiles not appearing until after the coal formation: and that it required many successive generations of plants to render it respirable for birds and beasts, is also likely, as it is not until long after, that any vestiges of these animals are found. These were the immediate precursors of the human race, the sovereigns of a world which they underprize, and of which they little know the wonderful structure or the surpassing beauty."

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of trees technically called *logs.* In February or March, the quantity of these logs is sometimes so great, that not only the river itself, but the sea for several miles off, was so completely covered over with them, that it required some skill to get through. The whole ground,—if the loose and muddy soil could be so called,—appeared to be formed of layers of these logs, matted together into a network, or rather a gigantic raft of rough timbers, many yards, and perhaps fathoms in depth, over hundreds of square leagues. May not this stratum of vegetable matter," asks the philosophic traveller, "which there is every reason to suppose stretches over the whole delta at the level of the sea, become in some future geological revolution of the world a great coal-field."

Speaking of the great river Atchafalaya, and its enormous raftage, Captain Hall adds: "the river just mentioned flows out of the Mississippi at a point about 250 miles from the sea. Twenty-seven miles from the efflux the raft begins, and extends over a space of twenty miles: but as the whole distance is not filled up with timber, the aggregate raft is only ten miles long. The width of the Atchafalaya is 220 yards; the raft extends from bank to bank, and is supposed to be about eight feet thick. It has been accumulating for more than fifty years, and is made annually larger, by supplies of trees drifted into the river from the Mississippi." In all likelihood, this immense aggregation of drift-wood will continue to increase, until in process of time it may become covered with sand, and afterwards with vegetation of the higher order, as already at certain seasons it is gay with verdure and flowers,* and after a succession

* De la Beche disparages the idea which has been promulgated relative

[illegible]r has assumed, as a not impro[illegible]ce, that the coal beds in every [illegible] to us where the chief localities and [illegible]he primæval vegetation were situate. [illegible] occur, there may we presume the [illegible]were profusely standing when the [illegible]trophe came upon them. A deluge [illegible]uses to us, for this destructive but [illegible]l change.* The great torrents of

* [illegible]viatile origin of our coal deposits, has been strongly [illegible] the character of the vegetable remains, but more [illegible]ence of fresh water shells, &c. and the apparent [illegible]s. It seems, however, that the latter conclusion [illegible]lly—marine remains, having lately been discovered [illegible]formation about Leeds and Halifax. This circum[illegible] fact of large petrified stems having been found [illegible] through various strata, have afforded fresh [illegible] theory rather of a sudden diluvial cause in the [illegible] that of an indefinitely slow process of deposition [illegible] rivers. Some of these petrified stems, which are [illegible] beds of coal, of shale, and of sandstone, have been [illegible] where they grew. This, however, has been [illegible] with reason, as "an unnatural idea"; for where, [illegible] find a tree of fifty or sixty feet in length, *in a* [illegible] patiently the tardy process of *slow lacustrine* [illegible] top shall be as well preserved for the inspection [illegible] roots which are nourished in the loose sands [illegible] then," proceeds Mr. Fairholme, "we find an in[illegible] the theory of a *slow* deposition, in undefined [illegible] entire trees which intersect various parts of [illegible] species of action are we to attribute the *rapidity* [illegible]*nometers*, if I may so call them, so plainly [illegible] this rapidity of action merely to the formation [illegible] such trees have been found, or are we, on the [illegible]ple by fair analogy, to other portions of the [illegible] interesting and instructive indexes! We [illegible] from analogy, that if any one portion of [illegible] throughout a similarity of character, can be [illegible] deposited in so short [illegible] of time [illegible] a vertical [illegible] 70 feet [illegible] series must have [illegible]ited in [illegible]lly identical. If [illegible] then, a [illegible] we continue [illegible] the

mingled earth and water, which, at that period must have been rolling around, as they poured and settled on the primitive valleys and plains, and produce that pressure, moisture, exclusion of air, confined moderate warmth, and sandy superincumbents, which appear to have been the producing causes, as they would now be, for converting plants and wood into coal.*

In contending for the ligneous origin of coal, it will not of course for a moment be imagined after what has been already stated, that the mere accumulation of an immense quantity of wood under any circumstances with which we are precisely acquainted, or exposed to the known agencies for any length of time, is sufficient to lead to the formation of a stratum of bituminous mineralised matter of the nature of that now under consideration; other conditions which have hitherto eluded the records of the historian and the investigations of the chemist must undoubtedly concur. The observations of Dr. Correa de Serra on the wood of the submarine forest at Sutton, on the coast of Lincolnshire, together with many similar accounts which have been published in the Philosophical Transactions and other works, demonstrate in the most satisfactory manner, that whether vegetables are totally or partially buried under the waves or under the earth, they are not merely by such means converted even into the most imperfect

coal strata as lacustrine deposits, from fresh water, formed in the course of *thousands*, or, as some think, *millions* of ages? It must be evident that either the facts alluded to are erroneous, or the usual line of reasoning on the coal measures, unfounded. The facts, however, speak for themselves, and are fully open to the inspection of every one: it may therefore be fairly assumed that suspicion must rest upon the theories in question."—*Fairholme on the Nature of Coal, and on the Mode of Deposition of the Coal Strata, in Phil. Mag. Oct.* 1833. *p.* 245.

* Sacred Hist. p. 232.

sort of coal. Some process, therefore, independent of these circumstances, must have taken place, in order that the vegetable substances, such as ligneous matter, resin, oil, &c., should become coal and bitumen.

The agency of fire was naturally enough at an early period of the investigation, supposed to have been one of the co-efficients in transforming vegetable matter into coal. Modern chemistry* had made comparatively but a small progress, when the illustrious Bergmann published his Dissertation entitled *Producta Ignis subterranei chemicè considerata;* for, at that time, the extent and power of chemical action in the humid way, were very imperfectly understood. In that part, however, of the above work, where he speaks of the fossil wood of Iceland called surturbrand, he evidently appears doubtful how far volcanic fire may have acted upon it; although he conceives that in the formation of it, there has been some connection with volcanic operations. His words are, "Quid de ligno fossili Islandiæ sentiendum sit, gnaro in loco natali contemplatori *decidendum relinquimus.* Interea, ut cum vulcani operationibus nexum credamus, plures suadent rationes, quamvis hucusque modum ignoremus, quo situm texturamque adquisiverunt hæc strata." It was certainly very natural, proceeds Mr. Hatchett, that Bergmann should entertain this opinion, in respect to the surturbrand; and it is remarkable that a schistus embedding the real substance of alder leaves in an apparently half charred state, and seemingly unknown to the celebrated chemist above named, appears to be of the same nature,

* Hatchett's Observations, Phil. Trans. vol. 94, p. 408-9.

and is found in the same country. The leaves described by Mr. St. Fond, as enclosed in a sort of marle, are also similar, and found in a country which, according to him, was formerly volcanic. Were these substances, therefore, never found but in countries which either actually are or were volcanic, we should be almost compelled to believe, with the Swedish Professor, that the operations of subterraneous fires have been concerned in the formation of these bodies, or rather in the conversion of them into their present state.

But similar circumstances are found in countries where not the smallest vestige of volcanic effects can be discovered, and Devonshire most undoubtedly is such; yet, nevertheless, the Bovey coal is there found similar to the surturbrand in most of its external and chemical properties, and in forming regular strata. Moreover, the half-charred appearance presented by both these fossils, cannot be adduced as any proof, that the original vegetable bodies have been exposed to the partial effects of subterraneous fire; for it is now well known that the oxidisement of substances is performed, at least as frequently, and as effectually, by the humid as by the dry way.* Fossil charcoal, or wood which appears to have been exposed to the direct action of fire, does indeed occur, as well in the coal measures of this country as in other parts of the globe†; it must not, however, be

* Trans. of the Linnæan Society, vol. iv. p. 141.

† Near to Cerro in Peru, there are numerous beds of fossil charcoal, of a quality that may be used for heating steam engines, and the like purposes. The principal bed lies between strata of fine sandstone. Geologists have been somewhat perplexed to account for these torrified deposits; it has been thought that a phenomenon recorded by Dr. Richardson, the naturalist, in Captain Franklin's expedition of discovery, respecting the shale on the

confounded with the lignites now under consideration. It remains, now, that we notice one other theory, which certainly appears plausible, if not probable.

Allusion has already been made to the experiments of Mr. Hatchett, and his own acknowledgment that the synthetic result was imperfect. Neither that able chemist, nor Dr. Mac Culloch, could ever obtain *bitumen* from carbonated oak, which substance is nevertheless an essential ingredient in true coal: the former gentleman, therefore, concluded his researches by entirely referring the production of bitumen to some unknown process of nature in the transmutation of wood. "But, with all the deference which is so justly due to that eminent chemist, I must beg leave," says Granville Penn, "to suggest, that it would seem to be time enough to resort to that ultimate principle when all previous means of research shall have been exhausted, which does not yet appear to be the case. Experiments have, indeed, been skilfully made on vegetable matter; but they have hitherto been made on *terrestrial vegetable matter* only. It seems to have been entirely forgotten in these investigations, that terrestrial vegetation is only *one part* of universal vegetation; and that immense tracts of *marine vegetation* flourish in all parts of the bed of the sea. We may form a sufficient judgment, from the vast quan-

coasts of the Arctic Sea, may bear on the question. This shale composed precipitous banks, which in many places were actually on fire. The combustion originates, according to Dr. Richardson, in the circumstance of the shale containing a considerable quantity of sulphur in a state of such minute division, that it very readily attracts oxygen from the atmosphere, and inflames. "Nothing, I think," says Mr. Rennie, "could explain in a more satisfactory manner the occurrence of charcoal in coal measures and other mineral strata. In the anthracite mines of North America, for example, wood charcoal occurs, with the ligneous structure as well marked as in the charcoal recently prepared."

tity of fuci and other marine plants vulgarly united under the denomination of *sea weeds*, which are continually cast upon our coasts, and which are commonly used for *fuel* in the islands of Jersey and Guernsey, of the immense quantities of these tribes of vegetation that must be contained in the different basins and depths of the sea. That the great majority of naturalists, who inhabit the interior of the European continent, should overlook this vast portion of vegetation amidst the interminable forests with which they see themselves surrounded, would be less surprising than that *we* should neglect to remark it, the foundations of whose soil are every where encompassed by it." "Now, since all naturalists," proceeds Mr. Penn, "are agreed in this one point, that our present continents were heretofore the bed of the sea; since beds of coal are found to lie in concavities varying greatly in extent, from a few to many miles, and containing numerous strata of coal, alternating with sand-stone, clay, &c. which describes a formation analagous to an ancient sea bed; since marine substances are found in the adjoining strata; since numerous sea shells,* and even bones of marine animals, are found in *imperfect coal*, as in that of Pomiers, in Dauphiny, although none remain recognizable in *perfect coal*;—a strong argument of probability seems to arise, that, if the substance of coal is of vegetable origin, we are to seek for that origin in marine vege-

* Some of the lower beds of the coal may have been derived in part from marine forests, if the occasional occurrence of salt-water testacea be admitted as proof: "but there are at least upper and middle coal strata 1000 feet in thickness, and several hundreds of square miles in extent, without a single vestige of marine remains." It is at the same time confidently affirmed, that no unexceptionable specimen of a marine *plant* embedded in rock has ever yet been produced.

tation; that the beds of coals, in their extensive concavities, were immense accumulations of *fuci*, &c., loaded with the various *animal substances* that shelter among them, which were overwhelmed by vast aggerations of the loose soils of the sea in the course of its retreat, and were left for decomposition and recomposition by the chemical action of the marine fluid which they contained, and with which the enclosing and compressing soils were saturated: under which compression they had lain in course of bituminisation and mineralization, for some thousands of years before they were brought to light 'entirely dissolved and recomposed in their elements, so as to be converted into the fossil masses to which we give the name of coal.' In this class of vegetation, so circumstanced," adds our author, "it is perhaps possible, that the ingredient might yet be found, which was uniformly wanting in the carbonisation of wood of earthy growth."*

The notion, once more prevalent than at present, that the coal strata are derived from the covering up of ancient peat bogs, appears to derive no support from evidence—for the analogy subsisting between certain relations in the carboniferous series, and sections of some interstratified turbaries, however it may illustrate the process by which vegetable matter becomes converted into coal, affords no indications of a common origin. For, however unreasonable it might be to expect to find the remains of any of the numerous mosses which enter into the composition of recent peat, in strata where almost every trace of the original organisation of plants presumed to have been

* Penn's Comparative Estimate, vol. ii. p. 187.

so much better fitted to resist decomposition is obliterated, still the associate shales do frequently present us with impressions of matters scarcely, if at all, less delicate in structure. It is, moreover, judging from the present state of things, not probable that tracts of moss covered large portions of the earth at the era of the coal formation, in common with plants, the remains of which are allowed to indicate the concurrence of intertropical vegetation, but not of the bog-formations of temperate and polar regions.

That the common bituminous coal, so abundant in this country, and in the eastern Continent, as well as in some parts of North America, owes its origin to vegetable depositions of some kind, at whatever time, or under whatever circumstances these have taken place, may be said to be all but universally admitted at present. Many eminent geologists, however, are hardly yet satisfied to refer the vast mountains of matter, apparently so much farther removed from ligneous identity as the anthracite appears to be, to the same cause. To this reference they have found an objection which, to them, seems of itself insuperable, in the vast quantity of this useful mineral. But is this objection really insuperable? Does it not proceed from a limited view of the operations of nature, from a disinclination to allow sufficient time for the execution of her stupendous designs? Many errors in geological science are justly attributable to an erroneous or limited estimate of time; and yet the eloquent chronicles of inanimate nature tell us of changes in the constitution of the globe which we inhabit, for the accomplishment of which ages must have been requisite. How many years must have rolled away, after the disruption of the original rock,

before the sandstone formation attained its present degree of compactness. Those, therefore, who deny that the anthracite is of vegetable origin, must bring forward some other objection than the want of time: and if they found their objection upon the depth and extent of this formation, we urge the analogy of the bituminous coal, and thus sustain the claim of the anthracite to a vegetable origin. It will not be denied that the power which could create mineral carbon, could also create vegetable carbon, and afterwards by some great convulsion, subject it to an irresistible force. The foregoing are the sentiments of Mr. Bunker, an American writer, whose opinions are given in Silliman's Journal. "Indeed," continues this gentleman, "it seems to me more in unison with the other arrangements of Providence, that the vegetables which beautified the face of the earth, for the happiness of one race of beings, should afterwards, when those beings had passed away, be stored up for the use of other successive generations of men." But the object of Mr. Bunker's communication to the Journal above-named is not, he says, "to engage in the discussion of the question, whether anthracite coal is of vegetable origin, except so far as may be necessary in the exhibition of the testimony which I am able to produce in support of that opinion. Mr. Bakewell, in his introduction to geology, asserts, that no vegetable impressions have ever been discovered in the anthracite, and I believe that most geologists are of the same opinion. I have been so fortunate as to obtain from a small quantity of Schuylkill coal, six specimens, proving that trees were at least present when the coal was formed, if vegetable matter is not *material*. The best specimen

presents the longitudinal section of a piece of wood, ten inches long and two inches broad. Another specimen exhibits a similar section six inches long. A third contains a bit of wood one inch square, and one tenth of an inch in thickness, and this piece could be easily detached. Another specimen exhibits a section of wood, from four to five inches long, and about three inches in width. The grain of this piece resembles that of the oak. A fifth contains a section four inches by three. The sixth is the counterpart of the fifth: the two pieces being the parts of a larger specimen, the cleft of the coal dividing the wood equally and similarly, leaving a portion in each division. These specimens exhibit not impressions merely, but real wood, resembling charcoal, although softer. In examining coal, I have often found indentations, which by the aid of the imagination, could be magnified into vegetable impressions; but I never before found real wood. About the specimens which I possess, there can be but two suppositions. Either this wood was introduced in some incomprehensible mode into the heart of the solid mass of the coal, or else it is a remnant, not wholly consolidated, of the material from which the coal was formed. I believe that the latter supposition is more philosophical, and consequently more rational than the former." *

* Silliman's American Journal, 1833.

CHAPTER V.

ORGANIC REMAINS.

Opinions of the Ancients concerning Organic Remains —Equivocal generation—Operation of plastic and forming energies—Conditions of vegetable remains —Families of plants existing at the period when the Coal beds were deposited—Plants of the upper Coal —Cycadiform fronds—Ligneous fossils of the true Coal formation—Mr. Witham's observations—Modifying causes of the variety of casts of stems discovered in different substances—Figures and descriptions—Microscopical examination of the minute structure of fossil bodies—Probability that trees of the more complicated woody structure, as well as the merely vascular and cellular kinds, existed at the period of the Coal formation—Fossil fishes—Muscles—Question of toads found alive in the Coal rocks—Hutton's observations on the traces of existing vegetable tissues in the perfect kinds of Coal.

It may now be interesting to advert somewhat more particularly to those phenomena which bring the coal formation into such immediate contact with the traces or remains of organic matter: and, although it is almost entirely in the rocks subjacent to, or incumbent upon, the carboniferous strata, that we meet with

such abundant and diversified remains of the animal world, yet has the latter series always, when penetrated, attracted the attention of philosophers to its appropriate suites of vegetable exuvia.*

The ancients, who were carefully observant of natural appearances, could not fail to become in some measure acquainted with the fossil remains of organic bodies—those "medals of creation," as the illustrious Bergmann has strikingly designated them. They were, however, sadly puzzled to account for their origin. Hence, they supposed the various *lapides figurati, lapides idiomorphi, lapides qui figuram habent conchæ, cochleæ*, &c., as they were cautiously called, to have had some equivocal seminal origin, and to have grown, during an anomalous sort of life, in the situations where they were found: while other and later writers referred the production of those organic fossils to a principle which they announced under such conveniently ambiguous terms as the *vis plastica* and the *vis formativa*. These theories were not merely applied to solve the knotty problem of animal reliquiæ, but also to account for those accumulations of bituminous wood which were so frequently discovered, and the striking dendritic forms of which were supposed to have arisen from tendencies to such formation inherent in the bitumen. Andrea

* The organic remains of the coal formation are prodigiously numerous—especially of *Plantæ*. The list given by Mr. De la Beche, and comprising fossils from this formation in all parts of the world, exhibits the names of the following numbers of species; *Euphorbiaceæ*, 9. *Coniferæ*, 4. *Doubtful Coniferæ*, 10. *Dicotyledonous plants of doubtful affinity*, 20. *Palmæ*, 3. *Cannæ*, 1. *Monocotyledons, of doubtful affinity*, 14. *Equisataceæ*, 15. *Filices*, 118. *Lycopodiaceæ*, 61. Plants of uncertain affinity, 42. Of animal remains the list presents, *Pisces*, 3. *Mollusca*, 14. *Conchifera*, 14. Among the latter are many marine remains which may perhaps belong rather to the strata alternating with the inferior rocks, than to the coal measures, in which, however, some of them have certainly been found.

Mattiola, an eminent botanist, embraced the notion of Agricola, a German miner, who had written on the subject, that a certain "materia pinguis," or fatty matter, made to ferment by heat, gave birth to fossil organic shapes. Of this opinion was Fallopio of Padua, who not only conceived that petrified shells had been generated by fermentation in the spots where they are found, but gravely supposed that certain curious antique vases dug up at Monte Testaceo near Rome, were natural impressions stamped in the soil! Among the last supporters of the opinion of the generation of these organic bodies in the bowels of the earth, observes Mr. Parkinson, may be mentioned the celebrated Langius, who strenuously contended for their having thus obtained their forms and existence; Dr. Plott, who believed their figures to result from the operation of certain plastic powers with which certain saline bodies were endowed; and, lastly, Lhwyd, who combated the *vis plastica* of Plott, and supported the idea of their production from the semina of fishes, &c., raised with vapours from the sea, and conveyed, by the clouds and rain, through crevices or fissures into the internal parts of the earth. The more rational conjecture of Woodward, who attributed their situation to the effects of the general deluge, was rendered of less effect, in opposing these notions, from his having attributed to the waters of the deluge, an almost universal solvent power; by which, he supposed the rocks and mountains were melted down, and thus allowed the admission of these substances, not considering that by the same power, the organic bodies themselves would have been reduced to a mass not bearing their proper figures.*

* Parkinson, Org. Rem. I. 23.

and mountain limestone"—in other words, is associated with the more ancient carboniferous deposits. "A cursory observer," adds Mr. Phillips, "may, perhaps, be led to confound together the ferns and calamites of the coal district with the ferns and equiseta of the oolitic rocks: though to a botanical eye their difference is very apparent: but who can mistake the lepidodendra of the former, the cycadiform fronds of the middle period, and the dicotyledenous leaves and fruits which abound above the chalk?"* As a specimen of a remarkable family of plants, the remains of which occur so extensively in the oolitic and liasic beds lying above the true coal formation, *fig.* 3. in the margin is given from Phillips: it is *Cycadites lanceolatus*, and occurs with a variety of other species, about Whitby. Cycas, a term applied by Theophrastus to a palm tree, is now used to distinguish a natural order of vegetables, introduced by botanists and phytologists as a connecting link between the ferns and the palms; they appear at the era of the Jura formation, which is regarded as the equivalent of the oolite rocks of English geologists, and seem to have borne an excessive relation to contemporaneous types, as compared with the present state of things. M. Brongniart is said to have obtained from the formation in question, seventeen species of fossil Cycadeæ, eleven

Fig. 3. [¼ natural size.]

* Geol. Yorks. 155.

of them belonging to the genus Zamia: so that a family, which now forms scarcely a thousandth part of the existing vegetation, and which flourishes only near the equator, at the period when the roestone was deposited, formed one half of the European vegetation.*

Among the more striking vegetable remains distributed in the coal formation, may be mentioned those usually identified with, or allied to, the genera of palms, pines, tree ferns, arborescent grasses, cactuses, and some of the verticillate plants.† Almost all authors agree in representing the magnificent family of palms as having existed at a very early era of the vegetable world, and as being found buried with the others: and their remains, viz. fragments of stems, fronds, and fruits, are said to occur in the older coal formations. The singular structure of the wood of this genus of trees renders the identification of the fossil specimens apparently less difficult, though not absolutely certain: the Rev. W. D. Conybeare refers the trunks or stems thus discovered partly to arundaceous plants, approximating to those now known; and to a very peculiar order, distinguished by the cortical part being entirely covered by regular impressions, resulting from the petioles and fallen leaves, ranging round them in spiral lines—these have been supposed to belong partly to the palmaceous order, and partly to anomalous forms, constituting

* De Candolle, in Edin. Phil. Journ. vol. xviii. p. 89. 1835.

† The Rev. J. Hodgson, author of the History of Northumberland, says:—"We have seen ears of barley, and the leaves of pine apples," [ananas, or merely fir cones?] taken from the schistus enclosing the coal near Newcastle. Beautifully distinct impressions, analagous to those which Mr. Hodgson so confidently attributes to "ears of barley," are before the writer of this note.

a transition link between these and the coniferous plants, similar to that already established in Professor Sprengel's Natural System. *Fig.* 4. is a fossil vegetable, from the coal near Buxton, in Derbyshire, where the impressions are frequent. Martin* says the original was "doubtless one of the fir tribe." It may be doubted whether it were a small cone or strobilus, or merely a portion of a branch: analgous specimens frequently occur; and the ironstone nodules about Ketley, in Shropshire, sometimes contain beautiful lepidodendra and lepidostrobi, the place of the original vegetable being occupied with a dark sparry concretion, occasionally investing some portion of the woody stem.

Fig. 4.

(½ natural size.)

A genus of plants, called by Dr. Martius, Yuccites, and which, he says, constitute a series allied to the palms, differs in structure from most of the monocotyledones, in having the stem broadly expanded above by a more or less perfect dichotomy, also makes its appearance among the primitive forms. Nor is it at all to be wondered at that such specimens should occur in our coal mines, apparently of the same order with plants of which we still have living examples, as evidence of a former world, the most ancient of all our vegetable productions, and of which may be adduced as an instance the famous dragon tree of Oratava.

It must not be forgotten that when attempts are made to discriminate the genera of vegetables, supposed to have entered chiefly into the original com-

* Petrificata Derbiensia, tab. 14.

position of the combustible beds of the carboniferous strata, no idea is thereby intended to be conveyed as if actual stems, impressions of plants, or ligneous structure, were ordinarily discernible in the mass of the true coal. Generally speaking, indeed, the very reverse of this is the fact. The vegetable matters, whose forms are so distinctly preserved, occur, for the most part, in the non-inflammable layers of the formation, the shale, the sandstone, the ironstone, &c.* It is the form and structure of fossil plants so situated, from which has been inferred the type of genera so changed by the union of chemical and mechanical causes as to exhibit no seeming trace of the original organization. "Except in a few instances," says Mr. Witham, "I have ineffectually tried, with the aid of the microscope, to obtain some insight into the structure of coal. Owing to its great opacity, which is probably due to mechanical pressure, the action of chemical affinity, and the percolation of acidulous waters, all traces of organisation appear to have been obliterated. After frequent trials, how-

* In some instances gigantic stems occur, partaking of the nature of the strata through which they pass; in others they are composed wholly of sandstone; and again, as in the case of the celebrated Craigleith fossil tree, they are coated with coal: it is commonly the bark changed into coal which presents that beautiful figure-work so characteristic of the carbonaceous reliquia. In the measures immediately below, as well as those above the High Main coal in the neighbourhood of Newcastle, many large stems (*Sigillariæ*) have been found in a vertical position. At Killingworth colliery they rose ten feet, passing through nearly as many strata of shale and sandstone, and their roots spread out in the shale. To adopt the words of Mr. de la Beche, "we can scarcely refuse to admit with Mr. Wood [who first decribed them] that these stems are exactly in the position in which they grew, the shale being the soil or mud in which they vegetated." It appears more probable, that having been torn up by the causes which accumulated the sedimentary beds, these trees may have floated from a distance on the water, or perhaps on the silt or mud into which their roots, first sinking by their superior gravity, determined them in the upright position in which they are found.

ever, I have at length been gratified by the discovery of a regular and beautiful texture in the centre of a piece of coal from the mountain limestone group. This, in many respects, indicates woody tissue, and undoubtedly leaves scope for our most sanguine expectations." The traces of organisation are, however, obscure in the slice of coal represented by this gentleman, especially as compared with the astonishing regularity of structure displayed by many fossil stems, exhibiting in several instances a texture as perfect as can be obtained from the most delicate section of a recent plant.

The late Rev. Henry Steinhauer, in a "Memoir of Fossil Reliquia of Unknown Vegetables in the Coal Strata," communicated to the American Philosophical Society in 1817, figures a specimen under the name of *Phytolithus tesselatus*, and the original of which, he says, assists in elucidating a circumstance very frequently attending these petrifactions, in which part of the original vegetable matter is transformed into stone. In such fossils the cast is sometimes very neat and complete, as in the present instance; while the matrix, on the contrary, is very indistinct; at other times the cast is very obscure, while the matrix exhibits all the marking very exactly. From these observations, it would appear, that, sometimes the cast set or hardened before the matrix, sometimes the matrix before the cast; and that one or the other continued soft after the vegetable matter had undergone that degree of liquifaction, which must evidently have taken place before it was converted into that coally substance which we now find. When, on the contrary, vegetable matter resisted decomposition till both the cast and the matrix had become fixed, both

must exhibit equally perfect traces of the original form, which is sometimes the case. It seems also impossible, from the above, to imagine the operation of fire to have had any share in effecting these changes.

Fig. 5.

Fig. 5. represents this fossil from Steinhauer, and which is supposed to be identical with the *Lepidodendron tesselatum* of Sternberg's arrangement, and rendered particularly interesting in connection with the following remarks. The tree-ferns, which constitute so beautiful a feature of the tropical regions, exhibit several characters, by which they may be compared with the ancient plants; but as they have been seen by comparatively few botanists, their structure is almost too little known to allow of their comparison with the vegetables dug up from our coal mines. Dr. Martius noticed one specimen in Brazil, so remarkable for the tesselated surface of its caudex, that he was not only struck by the novelty of the circumstance, but, on comparing it and eight other species with figures in Count Sternberg's work, he found them connected by so strong an affinity, as to entertain no doubts of their generic identity. This writer, in a paper* read before the Royal Botanical Society at Ratisbon, in 1824, describes thirteen species of fossil filicites, respectively exhibiting on their surfaces those striking configurations which render them remarkable in the cabinets of the curious, and still characterise many plants growing in South America.

* Translated in Edin. Phil. Journ. xii. 52.

Fig. 6. [¼ natural size.]

Fig. 6. represents a specimen of the *Euphorbites vulgaris* of Artis, which has not, he says, been figured by any other author, though found in the greater part of the coal fields of Europe. The cicatrices are flat, fish-shaped, the upper part trigonal; glands two, which, when the bark is absent, appear as twin tubercles on the ligneous fibres. These are a very striking species of stems: that, from which Artis made his drawing, was nine feet long, five feet in circumference at the lower extremity, and one foot nine inches at the upper. In one of the abandoned coal mines near Wentworth, seven trunks of this plant were suspended freely from the roof: some of them projected a foot, and the largest measured eight feet in circumference. In addition to various species of *sigillaria* analogous to the above, there are several varieties common in collections, consisting of slabs fluted as uniformly as if wrought with a carpenter's plane, and the ribs of which exhibit neither glands nor cicatrices. The writer of the article on coal, in "Rees' Cyclopædia," mentions, that curious visitors used to be shewn, on the roof of a lateral opening in one of the Kenton pits, near Newcastle, a variety of specimens of singular plants, somewhat like grasses, ferns, vetches, &c. imprinted upon a sort of blue slaty stone: the different plants are remarkably distinct from each other. There is also, in one part, the

trunk of a tree, many blocks of which have been taken out, to make seats in a neighbouring garden. As far as the stone has been cut, the tree has been traced, even to its smallest branches; and the roughness of the bark is still preserved in the stone: the whole of this stratum," adds the writer, "is one uninterrupted continuation of these impressions of vegetables: it is nearly horizontal, and 112 yards from the surface."

While the assemblages of the more delicate vegetable forms, which have left their impressions in certain strata, appear to have been heaped confusedly together, and while the stems of much larger tribes have been much compressed, and are mostly found lying in a position parallel to the enclosing stratum, there is a third class of fossil trees, individuals of which are often found in nearly vertical attitudes, apparently standing where they have grown, their roots distinctly expanded in the lower beds, while, in some instances, the stem rises through several different strata. Numbers of these *sigillariæ* have been observed in the High Main coal bed, as well as in other places.* They are the casts—mostly in sand-stone—of plants lined and jointed in the manner of bamboos, and sometimes two or three feet in diameter. The stem found in Craigleith Quarry, near Edinburgh, is forty-seven feet in length, the bark being converted into coal. Stems nearly as long, and four feet and a half in diameter, have sometimes occurred in the coal districts in the North of England.

* An appropriate depository—the Museum of the Natural History Society, at Newcastle-upon-Tyne, is rich in splendid specimens of this and the other fossils from the circumjacent coal district. There is, in the Museum of the Philosophical Society at York, a remarkably fine *sigillaria*, presented by Lord Milton, in 1832, from the collieries of Earl Fitzwilliam, near Rotherham.

Fig. 7.

Fig. 7. represents, of the natural size, the rhomboidal configurations of a highly beautiful specimen of Lepidodendron, *(Sternbergii?)* in the Museum of the Sheffield Literary and Philosophical Society. The entire impression is about eight inches by six, of polished coal, on a mass of dark clay ironstone: it is accompanied by a fair, but less striking, slab of *Lep. Obovatum, Sternb.* from the Elsecar Colliery, near Rotherham, where many very fine coal fossils of these kinds have been met with.

A very common but remarkable petrifaction occurs abundantly in the coal districts of the West Riding of Yorkshire, and in Derbyshire: it has also been found on the top of Ingleborough, in the coal strata of Northumberland, at Dudley, in Shropshire, in the neighbourhood of Bristol, and in several other places. With respect to the included or constituent matter, it seems always to coincide with that of the stratum in which it is embedded, with a slight modification of density: in a piece encrusted with coal, and now before the writer of this notice, the phytolithus itself consists almost entirely of iron pyrites, and is nearly as ponderous as metal. It is most abundant in the fine grained silicious stone, provincially called calliard or ganister, used for mending the roads, and often exhibiting films and encrustations of coal—this matter generally blackening if not investing the fossil, which always occurs as a compressed cylinder, varying in diameter from three to twelve inches. The surface is marked in quincuncial order with pustules, or rather depressed areolæ, with a rising in the middle,

in the centre of which rising a minute speck is often visible.* Mr. Martin suspected that these pustules were the marks of the attachment of the penduncles of leaves: at all events, long tubular acini, fibres, or leaves, are sometimes to be seen proceeding from the areolæ of the central cylinder in rays through the stratum in every direction, to the distance, it is said, of twenty feet, though the present writer could never trace them to that extent. These remains belong to the genus *stigmaria*† of Brongniart, and characterise the lower or ganister coal series of Yorkshire.‡ In making a large reservoir at Crooks-moor, near Sheffield, in 1833, thousands of tons of this stone were raised and carted away to mend the roads, during which time it was impossible to pass the heaps of broken matter without being struck by the prodigious numbers of the casts of these vegetables, and also with the profusion of long riband like leaves with which every piece of ganister appeared to be interlaced throughout, and which, from the black or pied aspect

* Steinhauer on Fossil Reliquiæ, p. 8.

† *Stigmaria Ficoides* of Lindley and Hutton, who have given (Vol. I.) some beautiful representations of different stems of this class. These Authors are of opinion that the stigmaria in question was a prostrate land plant, the branches of which radiated regularly from a common centre, and finally, became forked: that it was dicotyledonous; of a succulent nature; and that the tubercles upon the stem are the places from which the leaves, which are supposed to have been succulent and cylindrical have fallen off. The present may be as favourable an opportunity as may occur to the present writer, for expressing his admiration of the "Fossil Flora" of Lindley and Hutton: so exquisite are the illustrations, and so accurate and scientific the descriptions, that although Sternberg's splendid work will always be regarded as the foundation of our knowledge on this subject, it will no longer be the reproach of our Oryctologists, that the best, not to say only methodical description of our native fossils exists in the writings of a foreigner.

‡ In Phil. Mag. and Journ. for Nov. 1832, p. 349, is an article on the above member of the Coal Series, by J. Phillips, Esq. of the Yorkshire Philosophical Society.

Fig. 8.
[⅓ natural size.]

which they sometimes give it, have probably led to the provincial appellation of "crow-stone."

Fig. 8. is a nodule of bind, with the impression of some verticillate plant, copied from Martin;—it is probably one of the asterophyllites, much finer specimens of which genus are sometimes met with.*

Fig. 9. is the *pseudo royal* filicite of the same author, a species of *Neuropteris*, single pinnæ or leaflets of which in nodules of brown ironstone, are not uncommon; *N. gigantea*, the fronds of which are supposed to have been several feet long, differs chiefly from the foregoing in having pointed leaflets somewhat more distantly separated upon the midrib of each pinnate leaf. Vegetable impressions, as before remarked, are often met with in nodules of ironstone; and we sometimes witness analogous results in the occurrence of recent leaves very delicately preserved in those deposits of our ferruginous waters where ochre is formed: hence, as Dr. Darwin observed, the various ores of

Fig. 9.

"dusky iron sleep in dark abodes,
And ferny foliage nestles in their nodes."

* One of these, the *asterophyllites longifolia* of Lindley and Hutton, is figured in "Mammet's Geological Facts and Observations," as occurring in the coal field of Ashby-de-la-Zouch; this work contains one of the best series of accurately drawn and coloured representations of the coal vegetables which has been published in this country.

Fig. 10. [¼ natural size.]

Fig. 11. [⅓ natural size.]

Fig. 10. is *Sphenopteris crenata*, a species of fern delicately imprinted on blue shale: it is one of the most pleasing objects of its class, and, with the foregoing, delineated from beautiful specimens now lying before the writer of these pages.

Fig. 11. represents small specimens of three other vegetables occasionally met with in strata juxtaposed with the coal: A. a fern *(Aleutopteris vulgatior*, Sternberg); B. supposed to belong to a genus of plants, intermediate between the equiseta and graminæ, (*Volkmannia distachia*, Sternberg); C. small portion of a minute specimen of a handsome branching fern, *(Neuropteris gigantea*, Brongn.) This is a vegetable of frequent occurrence in most coal fields, and, with both the others, is generally met with in bluish indurated clay.

In consequence of the dictum of M. Adolphe Brongniart, expressed in a highly interesting essay on the nature of the vegetation which covered the

surface of the earth at the different epochs of the formation of its crust,* it had become, as it were, a received law of nature, not to be disputed, that no phænogamous vegetable existed during the oldest of his epochs, no remains of such plant having been discovered in the first of his four formations, comprising the numerous strata of grauwacke, encrinal limestone, and carboniferous rocks, magnesian limestone, and red sandstone. In contravention of the hypothesis as applying to the first of the above periods, Mr. Wynch has remarked,† that it is a well known fact in the neighbourhood of Newcastle-upon-Tyne, that the large trunks of trees found mineralized in the sandstone strata of that district, are branched in the same way as our forest timber, and must, of course, have belonged to the dicotyledonous subdivision of plants. Other evidence corroborative of this opinion has been produced.

It is, however, to H. T. M. Witham, of Lartington, that geologists are indebted for the means of a more extended insight into the structure of vegetable organic remains, than those commonly possessed. This gentleman suggested, and first practised with singular success, the method of cutting from fossil stems transversely and longitudinally thin slices, and having cemented them to pieces of glass, polished them so as to render the internal structure strikingly conspicuous under the microscope. The results of an ample series of experiments, undertaken with the view of developing any traces which the lapidifying and carbonizing processes may have spared in such remains of the ancient Flora of our globe, as are commonly met with, have been published by Mr. Witham,

* Translated in Edin. Phil. Journ. vi. 349, &c.
† Mag. Nat. Hist. iii. 373.

in an interesting volume, illustrated by exquisitely engraved specimens of skeleton structure.*

It is well known to botanists, that the stems of monocotyledonous vegetables present a system of sap vessels and fibres widely different from that of the dicotyledonous tribes; the former being exemplified by the internal structure of grasses, reeds, &c.; the latter, by the more solid texture of our larger trees. Such being the physiological fact, it has been a favourite theory with certain continental geologists to assume that, judging from the remains, every deposit, from the oldest to the most recent strata, exhibits a progressive developement of vegetable and animal forms, from the simplest to the most complex. Brongniart is the original propounder of this hypothesis, which is opposed by Mr. Lyell, Lindley and Hutton, as well as others, on satisfactory grounds; and however plausible the idea, it appears to be fast giving way before the investigations to which the method of the assiduous analyst above named has given rise.

"From what has already been done," says Mr. Witham, "we are led to believe that the surfaces of the earth, as they successively existed, were adorned in those remote periods, with trees containing woody cellular tissue, differing entirely from that presented by the vascular cryptogamic plants, such as the Equisetaceæ, Lycopodiaceæ, and Filices."

Our author willingly admits that, at the period of the deposition of the mountain limestone and coal series, "there existed Equisetaceæ ten feet high,

* "The Internal Structure of Fossil Vegetables found in the Carboniferous and Oolitic Deposits of Great Britain Described and Illustrated." 4to. with plates, 1833.

monocotyledonous plants and tree-ferns from fifty to sixty feet high, and arborescent Lycopodiaceæ from sixty to seventy feet high; but I must," he adds, "contend, that there also existed coniferous trees, or such as contained a complicated woody structure, in great abundance, and many of them of a height equal to the loftiest of those just mentioned. That the preponderance of vascular cryptogamic plants was considerable, I do not wish to question. Many of the shale strata accompanying the combustible beds of the coal-fields, contain innumerable impressions of Filices, Equisetaceæ, and Lycopodiaceæ; but that the beds, particularly at the bottom of the coal fields, also contain numberless specimens of gymnospermous phanerogamic plants, or of trees analagous to them, is now established beyond dispute. From the frequent occurrence, therefore, of trees possessing an exogenous structure, I cannot help suspecting the correctness of the assertion, that, 'the class which almost of itself composed the Flora of this period, is that of the vascular cryptogamic plants, and, in fact, that of two hundred and sixty species discovered in this formation, two hundred and twenty belong to that class.' "*

Proceeding to particulars, Mr. Witham mentions that vegetable fossils, evidently analagous to the tribe of pines, if not identical with the true coniferæ, have been found in the quarry of Craigleith, near Edinburgh, where some of the stems measured between forty and fifty feet in length, with a diameter, at their widest part, of at least five feet. Also, at Lennel Braes and Allen Bank, in Berwickshire; in several places about Newcastle-upon-Tyne; and

* Fossil Vegetables, p. 6.

especially about five miles west of the city of Durham, fossil plants are described as found and resembling the Coniferæ. "If, therefore," concludes Mr. Witham, "the argument that the combustible beds of our coal-fields are composed of vascular cryptogamic plants, rests upon the numerous impressions of the scattered remains of the leaves and stems of that class, why should the many magnificent members of the phanerogamic class be allowed to lie speechless in their early graves, instead of proclaiming the antiquity of their origin, and the usefulness of their remains?"

Mr. Steinhauer has described under the appellation of *Phylolithus sulcatus*, (*fig.* 12.) an interesting fossil of the coal formation, apparently either the terminal apex or first rudiment of one of the Bambusiæ, whose striated stems are so abundant. The cast, either detached or embedded in the matrix, and composed of sand, or of the argillaceous carbonate of iron, occurs of various sizes, from one inch to several inches in diameter, and occasionally somewhat differing in form.

Fig. 12.

Some persons, especially those who are disposed to regard as of the cacti family, those immense stems which are covered with pustular risings or depressions, have not scrupled to pronounce these fossils to have been flower-buds, resembling those of the recent *cactus speciosissima!* This seems a purely fanciful hypothesis. A friend informed Mr. Steinhauer, that these casts very greatly resembled the appearance of the Surinam bamboo, immediately on its rising above

ground. On the other hand, Lindley and Hutton appear to consider them rather as the base or bottom of the stem whence the roots proceeded. Brongniart has appropriately named this fossil *Calamites Steinhaueri,* in commemoration of its original describer, an excellent man and ingenious Oryctologist.

The existence of antholithes, or fossilized flowers, has been generally doubted, on the ground that the succulent substance of the stamens and pistils must be too delicate to undergo the lapidifying or carbonising process: but there exist impressions on shale and sandstone in the British Museum, on viewing which it is difficult to resist the conviction that they exhibit some kind of stellate blossoms. That casts of seeds, ears of wheat, barley, or other of the cereal grasses occur in the true coal formation, has also been denied. Seeds, however, do sometimes occur—but probably in no instance corn, notwithstanding the specious appearance of certain impressions to the contrary: indeed, it is asserted, that no trace of any glumaceous plant has been met with, even in the latest tertiary rocks, although we know that grasses now form a portion, and usually a very considerable one, of every Flora of the world, from New South Shetland to Melville Island inclusive.*

The remains of the animal kingdom found in the coal and associate beds are less striking than those of vegetable origin. Fossil fishes have been discovered in the carboniferous group, as well in Scotland as in this country—specimens from the coal in the neighbourhoods of Leeds and Newcastle being preserved in the Museums of both those towns. The large remains found in the ironstone of Wardie, and

* Fossil Flora, I. xiii.

in the coal fields of Greenside and Glasgow, and which were at first considered to be remains of saurian animals, are now determined by M. Agassiz and other Ichthyologists, to be true fishes.

About the middle of the coal series in Derbyshire, or in the ninth bed of shale, reckoning in the ascending order, a stratum of ironstone occurs, which is so full of different species of Mytili, &c. as to be distinguished by the name of the *muscle band.** There have been instances mentioned by various authorities of living toads found incarcerated in the coal strata: the fact of there ever having been in reality any such discoveries, is denied by Professor Buckland, who attributes the reports to mistakes on the part of pitmen, who having met with the animals in their workings, imagined them to have been dug out of the coal, without considering that they might but recently have entered the shaft. However this be, and the supposition is more facile than sound, the learned

* In the brown coal formation, which belongs to a more recent geological era than the true carboniferous group, animal remains are frequently found, especially in the lignitic deposits of the European continent. Mr. Lyell mentions that many entire jaws and other bones of an extinct mammifer, called by Cuvier Anthracotherium, have been found in the coal beds of Cadibone, the bone being itself changed into a kind of coal. In these beds, however, although comprising carbonaceous shales, and several seams of coal from two to six feet in thickness, no shells have been discovered, nor impressions of plants of which the species can be determined. The same authority also informs us, that near the valley of the Rhine, a tertiary formation, called brown coal, from the association with it of beds of lignite worked for fuel, contains various organic remains, particularly fishes and frogs: they are found in a bituminous shale, called paper coal, from being divisible into extremely thin leaves. It may be mentioned here, as an interesting distinction of the two groups, that while the vegetable matter which has been changed into the common coal, was until recently considered to have belonged exclusively to monocotyledonous plants of extinct species, all the distinguishable remains of plants in the lignite and associated beds are said to belong to dicotyledonous trees and shrubs, bearing a close resemblance to those now existing in the country.

Professor's experiment shewing that toads died when confined without air or food in closely glazed stone cells, no more disproves the repeatedly alleged discovery of live toads in coal, than it does their extraction from blocks of marble, of which latter fact, at least, there does not appear to be any reasonable doubt.*

In concluding this chapter, it may be interesting to mention that, at the beginning of 1833, some "Observations on Coal" were read before the Philosophical Society of Newcastle, by W. Hutton, Esq., from which it appeared that, on examining with the microscope one of those slices of coal in which Mr. Witham had discovered a distinct vegetable texture, the attention of the Author was excited by the remarkable appearance of several cells in that part of the coal where the texture of the original plant could not be distinguished. The coal of the Newcastle district is considered by the Author to be of three kinds: the first, which is the greatest in quantity and the best in quality, is the rich caking coal so generally esteemed; the second is cannel or parrot coal, or splent coal of the miners; and the third, the slate coal of Jameson, which consists of the two former, arranged in thin alternate layers, and has conse-

* The occurrence of living toads embedded, or rather entombed, in cavities of the deep strata has been adduced as a striking objection to the igneous theory of Hutton, and of course, as an equally striking testimony in favour of the hypothesis of aqueous solution, which commonly bears the name of Werner. Mr. Murray, the chemist, has remarked, that the lethargy of the toad and lizard may continue without the extinction of life for ages; and both these animals have been found embedded in stone: "a toad," says this author, "was found under the coal seam, in the ironstone over which it rested, in a coal mine at Auchincruive, in Ayrshire." Toads have often been buried in garden pots, and found alive after long intervals. Mr. Jesse mentions an instance of a toad so buried, which at the end of twenty years was taken up much increased in bulk.

quently a slaty structure. In these varieties of coal, more or less of the vegetable texture could always be discovered: thus affording the fullest evidence, if any such proof were wanting, of the vegetable origin of coal. Each of the three kinds of coal, besides the fine distinct reticulation of the original vegetable texture, exhibits other cells, filled with a light wine-yellow coloured matter, apparently of a bituminous nature, and so volatile as to be entirely expelled by heat before any change is effected in the other constituents of the coal. The number and appearance of these cells vary with each variety of coal: in the finest portions, where the crystalline structure, as indicated by the rhomboidal form of its fragments, is most developed, the cells are completely obliterated: the texture being uniform and compact, and the whole arrangement indicating a more perfect union of the constituents, and a more entire destruction of the original texture of the plant. After describing these cells, and illustrating them by drawings, Mr. Hutton proceeds to speculate on their origin in the cannel coal: he considers it highly probable that they are derived from the reticular texture of the parent vegetable, rounded and confused by enormous pressure: moreover, that though the perfectly and imperfectly developed varities of coal generally occur in distinct strata, yet it is easy to find specimens which in the compass of a single square inch contain both varieties. From this fact, as also from similarity of position in the mine, the difference in the different varieties of coal are ascribed to original difference in the plants from which they were derived.*

* London and Edinburgh Phil. Mag., April, 1833.

CHAPTER VI.

THE COAL FORMATION.

Review of the arrangement of carboniferous strata, as forming coal fields, coal basins, and coal measures—Arrowsmith's map of the coal districts—Somersetshire coal field—South Gloucestershire or Bristol coal field—Forest of Dean—South Welsh coal field—Shropshire field—South Staffordshire and Warwickshire—North Staffordshire—North Wales—Lancashire coal field—Yorkshire, Nottinghamshire, and Derbyshire coal fields—Whitehaven coal field—Northumberland and Durham—Unexplored localities in England—Scotch coal fields—Ayrshire—Paisley—Lanarkshire—East Lothian—Culross—Irish coal fields—Districts of Leinster, Munster, Connaught, and Ulster—Description of a coal basin—Somersetshire and South Welsh basins—Mantle, and inverted basin shapes—Swilleys or small basins.

WE have already adverted to the geological position of the carboniferous group of strata (vide p. 36), where it will also be seen that the terms used at the head of the present chapter are applied to one of those five general classes or suits, into which the

whole known series of mineral beds may be comprehensively resolved. The class of rocks here alluded to, and to which, for distinction's sake, the name of medial has been applied, range downward from the class terminating, as the case may be, with what geologists term the upper or newer red sandstone, conglomerate or magnesian limestone, and contain not only the great coal deposit, but likewise the older limestone, or as it is sometimes designated from the organic remains embedded in it—encrinal limestone, and the red sandstone, on which it reposes.* It may be remarked that the immense and diversified series of strata upwards, from the old red sandstone, constitute the region of vegetable remains, and to a great extent of the metalliferous deposits also.

It is not, however, intended to mould the matter of the present Chapter into any systematic form, nor to make it the vehicle of any particular theory: the terms "Coal Formation," may, therefore, conveniently be used to designate:—

I. Those generally insulated tracts of carboniferous strata, commonly known in this country under the appellation of "coal fields."

II. The scope and inclination of the strata, denominated from their flexures, and occasional spherical formation, "coal basins;" and

III. The succession and order of strata, as dis-

* It is an interesting fact, as connected with geological enquiries, that these depositions are not always found conformable with the underlying masses, as to parallelism of their surfaces. In some situations, the newer red sandstone fills up the superior inequalities of the subjacent strata, as if the matter which afterwards consolidated into the stone above named had, in the first instance, flowed over the previously contorted mountain limestone and coal measures, no disturbing force having subsequently been exerted to prevent the tranquil settlement and aggregation of the conglomerate.

played in a vertical section, and called "coal measures."

Of these three views of the coal formation, it may perhaps be remarked in addition, that the first is that which chiefly interests the topographer; the second the geologist; and, the third, the miner.

The map, engraved by Arrowsmith to accompany the Report of the Coal Trade, printed by order of the House of Commons, in 1830, shews in a striking if not very precise manner, the geological position as well as the commercial distribution of the coal of England and Wales. But it must be recollected that in computing from the coloured areas on this map, the entire space is often erroneously taken as underlaid with coal; for in most of the large fields, there are extensive tracts of barren or unascertained strata: this being the case, the districts afterwards described are rather given as those within which coal occurs, than as being entirely occupied by it. If, however, a person take an ordinary map of this portion of Great Britain, and draw a line from Weymouth, on the English Channel, to Jedburgh, on the Scottish Border, and then draw at right angles with that line, other lines, as follow:—1, on the west side, from St. Bride's Bay to Pontypool; 2, on the east, from Wolverhampton to Atherstone; 3, on the east, from Newcastle-under-Lyne to Cheadle; 4, on the west, from Chester to Mold; 5, on the east, from Huddersfield to Pontefract; 6, on the west, from Whitehaven to Appleby;—such lines will intersect nearly every portion of coal district in England and Wales. It may be further remarked that, if another line, parallel with the former be drawn, from Gosport on the south to Guisebrough on the north side of the

island, almost every portion of the true coal formation known to exist in Britain, will be found to lie on the western side of such line.*

In describing these localities somewhat more in detail, we shall proceed from south to north; and in this course, about eighteen miles from Bath, we approach a curved tract, stretching perhaps twelve miles in length, and being about three miles over in the widest part; this is the Somersetshire coal field. Proceeding onwards, we immediately come to the South Gloucestershire, or Bristol field: it lies to the east of the city just named, and may be said to be about a dozen miles in length, extending from the Avon northward, and three miles in average breadth. This is the nearest place to London at which coal has been found: and here, the strata dipping eastward, pass beneath the red marl. Assuming that the Somersetshire coal measures, continuing to dip at the rate they do at Bristol, ultimately pass under the Metropolis, where wells have been sunk to the depth of 130 feet before reaching the sand, Mr. Phillips supposes† that "the strata of coal are more than *two miles* beneath the bottom of the clay" underlying

* The coal formation in this country, lies generally in situations conveniently accessible: and although this is not exactly the case in other parts of the world—particularly in America, there is still much of truth in the speculation, which assumes that the rich and pleasant valleys, and low plains near the seas, and large rivers, were to be the habitations of the social and commercial, busy world of mankind; and there the coals are found, perfectly convenient for home consumption, and for supplying the wants of others, by the great commercial high roads—the waters. Had the coals been deposited in the bowels of the highest mountains, they would in a great measure have been useless to society, manufactures, and commerce. We could not conveniently have carried the coals from the distant mountains nor have lived near them. The high mountains are too barren, too cold, and too far from the seas, for the residence of man in a social, commercial state; but there is none, or very little of them there.

† Geology, 219.

London. The hypothesis, however, upon which this vast eccentric dip and direction are calculated, is justly regarded as untenable.

The next coal field is that of the Forest of Dean; it is somewhat of an oval form; the average diameter, six or seven miles. Directly west, of the last mentioned deposit, and at a distance of less than twenty miles, lies the great South Welsh coal field, extending from Pontypool on the east, to St. Bride's Bay on the West side of the Principality, and including the great iron works of Merthyr Tydvil. Mr. Martin, who has published a very exact survey of this formation*, states its length to be upwards of one hundred miles; and the average breadth, in the counties of Monmouth, Glamorgan, Carmarthen, and part of Brecon, from eighteen to twenty miles, and in Pembrokeshire only from three to five miles: the broader and narrower portions are separated by Carmarthen Bay, which is about twelve miles across, taking the line of the coal field.

Returning to the line first drawn, and still proceeding northward, we next come to the Shropshire field, including Coalbrook Dale, and the Plain of Shrewsbury: these taken together, may make eighty or ninety miles of coal. North-east of the last tract, lies what may be called the South Staffordshire, or Dudley and Warwickshire field. The first basin of this coal, occupies a space between the towns of Stourbridge, Birmingham, Wolverhampton, and Walsal; and extending in a triangular form on a base line drawn between the two last named places, the hypotheneuse lying about midway between Lichfield and Penkridge; and comprising altogether an

* Phil. Trans.

area of seventy or eighty square miles. The second basin occurs ten miles east of the preceding, and extends from Tamworth to Coventry, twenty miles; the average breadth being about three miles. Besides the foregoing, there are coal measures, north-east and south-west of the town of Ashby-de-la-Zouch*, making together, at least thirty square miles†.

What is called the North Staffordshire, or Pottery coal field, consists of two sections, the eastward of which, surrounding Cheadle, and the westward including Burslem, may be said together to spread over about sixty square miles. Some authorities, however, have estimated the area of the field as comprising from 40 to 50,000 acres of thick coal.

The North Wales, or Flintshire field, thirty miles west of the last-mentioned, comprises, 1, a tract extending from Wrexham to Hawarden, and thence, along the south-west bank of the river Dee, to the Irish sea: 2, a small section, stretching from Oswestry towards Shrewsbury; 3, a basin lying between the two preceding; and, 4, in the Isle of Anglesey; spreading together over at least one hundred and fifty miles.

The great Lancashire coal field, stretching from Manchester to Colne toward the north, and from the former place to Liverpool toward the west, is of an exceedingly irregular form, and running out into vast branches, one of which extends from Ashton-

* Mammet, after describing the range of the outcrop of the Ashby coal field, estimates the included area at not less than from 35 to 40,000 square acres.

† The collieries on the Wolds near Ashby-de-la-Zouch, are worked on an extensive scale by the Marquis of Hastings, and also by some private individuals. The depth of the pits is mostly from 300 to 360 yards.

under-Line to Macclesfield. From the zigzag character of the outline of this field on Arrowsmith's map, it is difficult to compute the area of the whole: it cannot, however, be less than from four to five hundred miles, including an insulated portion at Hornby, near Lancaster.

Eastward of the above, lie the important coal fields of Yorkshire, Nottingham, and Derbyshire, so called, as extending into those counties, but constituting one continuous extent of formation, stretching in length from Nottingham to Bradford, a distance of upwards of sixty miles in a straight line, and being on the average hardly less than eighteen miles in breadth.

The Whitehaven coal field stretches along the eastern shore of the Irish sea, from beyond Egremont to Maryport, where it sweeps inland to Hesket, forming an arc with a chord of about thirty miles: the average width about four miles.

We next come to the great northern coal field, extending into the counties of Durham and Northumberland, and containing those immense deposits of excellent coal, from which not only the metropolis, but a vast circuit of towns and villages on the coast from Berwick to Plymouth, are supplied with this species of fuel. In pursuing our prescribed course northward, we enter upon the southern extremity of this coal field a little beyond the Tees, at a place called Staindrop; proceeding over it, nearly in the middle, we pass through Durham,* Chester-le-street,

* "The colliery, or rather the three collieries in the neighbourhood of Hetton, in the county of Durham, is at present," says Mr. Wynch, "the most important mining concern in this [the northern] coal field. These pits are said to be capable of working two hundred thousand Newcastle chaldrons of coals annually: they are situated about seven miles from Sunderland, to the south-west, and the shafts are sunk through the magnesian limestone, which here covers the coal measures, and is twenty-six fathoms in thickness."

Newcastle, Morpeth, and reach the opposite margin at Warkworth, on the little river Coquet, a distance of nearly sixty miles. Passing over an interval tract of about three miles, we again come at the coal, and pass over it through Alnwick and Belford towards Berwick, a distance of twenty-five miles, making in the whole an extent of coal field running for about eighty miles in one direction. From Berwick-on-Tweed to the estuary of the Tyne below South Shields, the coal extends along the coast-line, dipping, indeed, under the German Ocean. The figure of this immense coal field is very irregular: but the extent in a cross direction would be nearly passed over by taking the line of the Roman wall, which commences near North Shields, and proceeding in a westerly direction to Brampton, near Carlisle. The whole area of this district, as thus including the coal formation, lying under what is called at Newcastle "the west country;" as well as the more important measures surrounding that town, cannot be under fifteen hundred square miles.

It is not by any means pretended that the foregoing are precisely accurate definitions of the outlines, much less exact computations of the size of the various coal fields named; but merely, as before explained, loose sketches, derived from the delineations on Arrowsmith's map, and serving at once to shew the topographical bearings and proportions of the several districts, and, at the same time, to indicate how extensive are the depositories of this valuable mineral in this island. Besides the tracts above indicated, there are various unexplored localities, which future research may add to our present coal fields: a highly interesting memoir on this subject, by the Rev. W.

Conybeare, is printed in the Philosophical Magazine for 1834.

Scotland contains some highly important coal fields, though occupying a comparatively insulated district; there being at least seventeen counties either destitute of coal, or containing it only in such small quantities, or of such indifferent quality, as to be of little value. To these may be added, the Orkneys, the Shetland Isles, and even the Hebrides, though the latter contain traces of seams. Generally speaking, the coal strata are not found north of Saltcoates, or south of Girvan in Ayrshire, on the west coast; nor north of St. Andrews, (except an inferior kind in Sutherlandshire*,) or south of Berwick, on the east coast; so that these four points may be said to define the coal country in Scotland, stretching from S. W. to N. E. across the island, in breadth between thirty and forty miles†. In some districts the produce is very abundant: the whole of the south side of the county of Fife abounds in coal; there are productive collieries at Saltcoates in Ayrshire, and in the vicinity of Paisley in Renfrewshire. Lanarkshire is famous for an immense field of coal, underlying a tract of limestone, iron ore, and freestone. East Lothian, one of the most fertile counties in Scotland, which rests, for the most part, upon a bed of granite, also

* It has elsewhere been intimated, that besides the true, or as it has been called the "Independent" coal formation, seams of an indifferent and apparently newer kind are sometimes worked *above* the magnesian limestone. As an exception to the generally limited size of the deposits of this upper coal, may be mentioned that of Brora, in Sutherlandshire, alluded to in the text, and which stretches for several miles along the coast of Scotland. This deposit in which extensive workings have at one time or other been pursued during the last three centuries, is believed to correspond in geological position with the carbonaceous series of East Yorkshire, described by Mr. Phillips, as occurring between the lower oolitic and the cornbrash limestones.

† Playfair's Scotland, vol. i. p. 174.

affords abundance of excellent pit-coal: three considerable collieries are worked in the parish of Tranent, seven miles west of Haddington, the chief town of this county. Campsie, Baldernock, Kilsyth, and Larbert, are situated on the great Lanarkshire coal field, from which the celebrated iron-works on the river Carron are supplied with fuel; nearly 200 tons of coal per day were consumed at these works some years ago. At Culross, a detached corner of the county of Perth, coal has been wrought for ages: these works, as they are among the most ancient, were also, at one time, the most considerable in Scotland; and an Act of Parliament, A.D. 1663, ordained that the Culross chalder should be the standard measure for the kingdom.

The following summary of the Irish coal fields is extracted from Mr. Griffith's admirable report on the Leinster coal district, and quoted by Conybeare and Phillips.* Coal has been discovered in more or less quantity in the following seventeen counties of Ireland:—Antrim, near Ballycastle; Donegal, north of Mount Charles; Tyrone, in the Ulster coal district, and at Drumquin; Fermanagh, a north continuation of the Connaught coal district, and at Petigoe; Monaghan, near Carrickmacross; Cavan, near Belturbet; Leitrim, and Roscommon in the Connaught coal district; Westmeath, near Athlone; Queen's County, Kilkenny, and Carlow, in the Leinster coal district; Tipperary, continuation of the same; and Clare, Limerick, Kerry, and Cork, in the Munster coal district. Of the four principal coal districts into which the island may be divided, viz., the Leinster, the Munster, the Connaught, and the

* Introd. Geology. part i. p. 462.

Ulster,—the two former contain carbonaceous or stone coal—the "slaty glance" coal of Werner; and the latter bituminous or blazing coal.

The Leinster coal district is situated in the counties of Kilkenny, Queen's County, and county of Carlow. It also extends a short distance into the county of Tipperary, as far as Killenaule. This is the principal carbonaceous coal district. It is divided into three detached parts, separated from each other by a secondary limestone country, which not only envelopes, but in continuation passes under the whole of the coal district.

The Munster coal district, occupies a considerable portion of the counties of Limerick and Kerry, and a large part of the county of Cork. It is by much the most extensive in Ireland; and in the neighbourhood of Kanturk, in the county of Cork, coal and culm have been raised for about a century. The formation itself is referable to one of the earliest periods at which the former mineral has been produced, the true coal overlying the mountain limestone.* At Dromagh colliery, Mr. Griffiths was informed, the work had been carried to a considerable extent, and that the annual supplies of coal and culm materially contributed to the agricultural improvement of an immense extent of the great maritime and commercial counties of Cork and Limerick, which otherwise must have continued neglected and unreclaimed. In addition to setting forth the interest and importance of the tract just mentioned, the writer of the report entertained a hope that the time was not remote, when the great coal field on the left bank

* Weaver on the Geological relations of the South of Ireland, in *Jameson's Edin. Journ. Oct.* 1830.

of the Black Water would be found to contain mineral treasure altogether inexhaustible.

The Connaught coal district stands next in order, of value and importance, to those of Leinster and Munster, and possibly may be found to deserve the first place when its subterranean treasures shall be explored. At present little is known beyond the fact, that the outer edges of several beds of coal have been observed, but they have not been traced to any distance; so that their extent has not been ascertained. The coal is of the bituminous species, particularly adapted to the purposes of iron-works; and the grey pig-metal made at the Arigna iron-works is reckoned among the best smelted in the empire.

The Ulster coal district is of trifling importance when compared with the foregoing. It commences near Dungannon, in the county of Tyrone, and extends, in a northern direction, to Coal Island, and in continuation to the neighbourhood of Cookstown. No beds of coal worth working have hitherto been discovered between Coal Island and Cookstown, but certainly the strata extend there. The principal collieries are at Coal Island and Dungannon, adjacent to the great basaltic area which characterises this portion of Ireland; the coal measures themselves being supposed to be identical with those that belong to the formations of the great central valley of Scotland. The coal of this district is bituminous.

Besides the foregoing principal coal districts, there are others of less consequence. Bituminous coal has been found in the neighbourhood of Belturbet, in the county of Cavan, and at the collieries of Ballycastle, in the county of Antrim; but the Antrim coal district is not very extensive, though the collieries have

been wrought for a number of years. The coal is of a slaty nature, and greatly resembles both the coal and the accompanying rocks which occur in Ayrshire, and probably they belong to the same formation. The whole of the coal districts of Ireland, so far as Mr. Griffiths was aware, are those above mentioned; trials have, however, been made at Slane, on the river Boyne, and also in the neighbourhood of Balbriggan and Rush. These trials were, however, on the edge of the district. Although coal is of very rare occurrence, as well as of indifferent quality, in the county of Clare, Mr. Weaver suggests the probability of discovering valuable seams in the elevated regions of Mount Cullun, where, if coal should be found, the beds being nearly horizontal, it might be worked with advantage. From the foregoing account of the coal districts, it appears that very extensive tracts of coal country exist in Ireland; but none, if we except the Leinster district, have been examined; yet the Munster coal district is in extent greater than any in England, and may probably contain inexhaustible beds of coal.

We have already stated, towards the beginning of this chapter, that these immense mineral deposits are often, with reference to their internal figure, denominated by geologists COAL BASINS. Recollecting that the beds or seams contained in a coal field, are not merely tabular masses, which lie evenly between their bounding planes, like a slab of marble, but in general, strata conforming successively to the scope of the hollow in which they are accumulated, it will be perceived that the edge or bounding line of each stratum must present itself at the surface, where denuded of the soil, appearing somewhat like the

concentric layers of an onion when cut in two: the edges of the coal and alternating beds being, however, much less uniform in thickness and level. This "coming to the day," or appearance of the coal at the surface of the ground, is called by miners, the *basset* or *outcrop*, and serves, where it is exposed, to determine the form or size of the basin outwardly. These basins are generally elliptical, sometimes nearly circular, but are often very eccentric, being much greater in length than in breadth, and frequently the one side of the basin upon the narrow diameter, having a much greater dip than the other; which circumstance throws the trough or lower part of the basin much nearer to one side than the other.* From this view of an entire basin-shape, it is evident, that the dip is in every direction, and all the strata regularly crop out, and meet the alluvial cover in every point.

The most complete and simple form of a coal field, with reference to its section, is the entire basin shape, which we have in some instances, without a dislocation. A beautiful example of this as seen at

* Some recent geological writers have doubted the propriety of the term "basin," as generally applied to the coal and other deposits, on the ground that the containing area is much too rarely of any entire and regular figure to justify the appellation. The immense hollows in which the carboniferous strata are commonly found accumulated, are supposed to have been lakes or valleys, into which, as mentioned in a preceding chapter, have been swept, under whatever circumstances, the gigantic vegetables originally growing in their vicinity. The celebrated vale of Clyde, in the county of Lanark—the most famous Scotch coal country, is partly an immense basin, or rather trough, as the measures underlying the river, basset along both sides at a considerable distance. And we recollect, on one occasion, to have heard the appellation of "coal basin," given to the bed of the German Ocean, on the ground that the carboniferous strata which dip eastwardly near the coast below Newcastle, are the same that are found descending in a contrary direction on the opposite shores of Belgium. It has been supposed that rich coal measures may pass under the British Channel.

Blairengorne, in the county of Perth, immediately adjoining the western boundary of Clackmannanshire, accompanies the observations* of Robert Bald, Esq. on the coal field of the last named district. In *fig.* 13. the elliptical line marked A B C D represents the crop or outburst of the lower coal, and the inner elliptical line the crop or basset of the upper coal: the converging darts indicating the dip of the measures towards the centre. *Fig.* 14. is a longitudinal section of the line A B; and *fig.* 15. the transverse section of the line C D; all the accompanying coal strata partake of same form and parallelism.

Fig. 13.

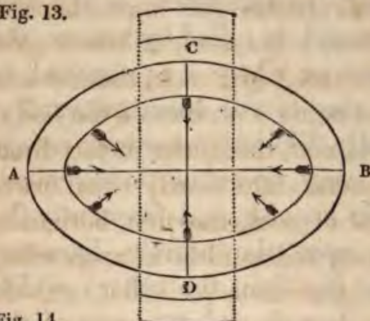
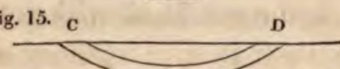


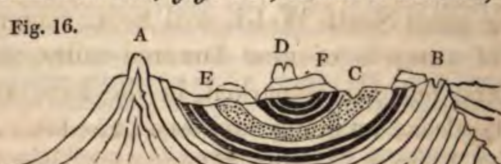
Fig. 14.

Fig. 15.



The annexed cut, *fig.* 16., shews a section, by the

Fig. 16.



Rev. W. Conybeare, of a basin belonging to the Somersetshire and South Gloucestershire coal fields. It extends from the Mendip hills, indicated by the

* Memoirs of Wernerian Society, vol. iii. p. 123. The communication of Mr. Bald has furnished many of the remarks in the text above.

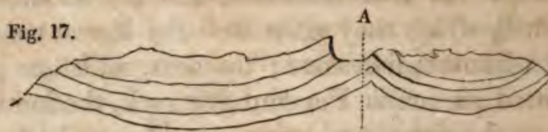
elevation at A, to the Wick rocks B; the great masses of both being old red sandstone. The stronger black lines shew the coal measures, and the others, the strata with which they alternate—the lowest consisting of mountain limestone; the next, millstone grit: the dotted portion is Pennant grit rock, the indentation C at the right hand being a section of the bed of the river Avon which bisects the basin in the direction of its shorter diameter into nearly equal parts. Above the higher lines of coal, the first horizontal stratum E consists of new red sandstone, upon which repose beds of what geologists call lias F: the middle portion here underlying the bifurcate section of Dundry hill D, consisting of oolite: both these last named accumulations are species of limestone, containing vast quantities of marine shells. The summit of Dundry hill is 700 feet above the level of the sea. It would be easy to give outlines and sections of various other basins in the British coal fields; but these, however interesting to the geologist, would afford but little gratification to the general reader, as they only differ in size and arrangement, and not in character, from those already noticed.

The great South Welsh coal field, comprising an area of upwards of nine hundred miles, and being, as some one has remarked, in the form of a long-necked flask, was long supposed to exhibit a nearly perfect basin.* Later examination, however, has

* The earliest writer who appears to have entertained any thing like a distinct idea of the arrangement and order of the coal strata, was George Owen, who, in 1570, left in manuscript a *History of Pembrokeshire*. He, however, seems to have been unaware of the subterraneous continuation of those beds, the superior outline of which he traced to a considerable distance, and which he improperly designates veins. "It is not, indeed, uncommon to find miners among the Welsh collieries, generally speaking, a very intelligent race of men, who have not yet become converts to Mr. Martin's idea

enabled Mr. Conybeare to give the subjoined section which, instead of being nearly hemispherical,

Fig. 17.



as Mr. Martin had assumed, presents a rising of the measures on each side of the anticlinal axis A, *fig.* 17.

It is from the basin shape, that all other coal fields are supposed to be formed, which are portions or segments of a basin, or cavity of some kind, and have been produced by slips, dykes, or dislocations: these will form the subject of a separate Chapter. It may be here remarked, however, that the strata in many situations, instead of shelving generally from all parts of the superior circumference to the centre, or, as miners call it, the *trough* of the basin, sometimes occupy a vice-versa position, rising from the sides to the summit, and, as it were, overlying a cone within: in this case, the formation is said to be mantle-shaped; or when the cone pierces the strata, and the crop appears, indicating divergency downward, this form of the coal measures is termed the inverted basin. These peculiar conformations, however, comparatively seldom occur: examples are to be seen in Scotland in the county of Fife, and in several districts of England; but even in extensive coal fields, the inverted basin-form is only a partial occurrence, or a deviation from what is conceived to be the general and ordinary form. Through the hill upon which Dudley

of a Mineral *Basin*: to the same cause may probably be attributed the term *gwythyen*, or *vein*, universally given by the Welsh miners to a seam or bed of coal."

Castle is built, canals have been cut for working the great beds of limestone: these beds occur in the lower series of the strata of the Staffordshire coal field, and, of course, are to be found at many miles distance from the Castle hill, and beyond the crop and outbursts of all the workable coal in the true basin-shaped part of the field; at the same time, by this invested basin-form, these beds of limestone are elevated far above the level of the common surface of the country, and consequently above the level of all the coals. The numerous beds of coal, one of which is of the very great thickness of thirty feet, lie next the Castle hill, in a conforming situation with the beds of limestone, and as this hill is of an eliptical form, the coals are found all around it. There are also two other hills, which lie with it in a direct line through the coal field—namely, Wrensnest hill, and Hurst hill. In the former, the same beds of limestone as those found in the Castle hill, have also been wrought to a great extent, by means of a canal cut through the hill, which gave Mr. Bald an opportunity of examining the internal form of the strata of the hill, which are described by him as being completely mantle-shaped. This hill is also of an elliptical form, and the beds of coal with their accompanying strata, lie all around it, conforming with the beds of limestone, cropping towards the summit of the hill. From the truncated figure of the top of the hill, which is now arable land, it would appear, that at one time it had been much higher; excepting where these hills occur, inverting the ordinary figure of stratification, the great Staffordshire coal field is of the true basin shape.*

Besides those extensive accumulations of carboni-

* Memoirs of Wernerian Society, iii. 148.

ferous strata, there are sometimes found outliers obscurely attached to the main formation, or detached portions forming small basins, not more than a mile in diameter, and called in the West Riding of Yorkshire, *Swilleys*. Seams of coal, inferior in thickness to those belonging to the Newcastle coal formation, and interstratified with the encrinital limestone, as well as with sandstone and shale, are spread over most parts of Northumberland; but owing to these "landsale collieries" being generally inconsiderable in point of depth and extent of workings, the continuity of the beds of coal has never been accurately ascertained. Sections of coal mines in this formation are to be found in the fourth volume of the Geological Transactions, where an account of Shilbottle colliery, which supplies Alnwick with fuel, is given: and in the Transactions of the Natural History Society of Newcastle, sections of the more important mines in the vicinity of Berwick-upon-Tweed are inserted. Mr. Wynch, from whose interesting papers these particulars are derived, gives a section of the colliery close to the old castle of Blenkinsop, 33 miles west of Newcastle. The deep pit at this place was 56 fathoms, and the viewer considered the position of the coal to be below the four fathom limestone, and above the great limestone of the Alston Moor mining field, and that the bed of coal was the same as that worked in the more extensive mines on Tynedale Fell. From these collieries Carlisle derives its coal.*

The unexplored coal beds enveloped in the limestone, become important in considering the unresolved problem of the extent and consequent duration of the northern mines.

* Lond. and Edin. Phil. Mag. and Journal, Oct. 1833, p 274.

CHAPTER VII.

COAL MEASURES.

Meaning of the terms "Coal Measures"—Arrangement, contortions, and dislocations of strata—Vertical section of a deep pit near Newcastle—Tabular view of substances passed through—Gosforth colliery Depth of the High Main Seam at Jarrow—Sections of Mines at Dudley and Bilston—Inequality in the thickness of matter occurring between certain Coal seams—Tabular view of strata at Whitehaven—Synopsis of Coal measures at Ashby-de-la-Zouch—Staffordshire, Lancashire, Derbyshire, and Yorkshire coal fields—Sheffield—Section at Halifax—Notices of the coal strata in South Wales, Scotland and Ireland—Occurrence of iron ores in the coal formation.

BY the term "measures," it is merely intended to designate the stratification of any particular coal district, comprising what belongs to the dip, thickness, and depth, and composition of the several solid matters exposed and raised in the progress of mining. It will be obvious that, on sinking a pit in any coal-field, consisting of cavities bounded in the manner described in the preceding chapter, the concentric beds, of

whatever composition, might be expected to be met with more highly inclined, as the working takes place further from the centre of the mineral basin, supposing its form to be tolerably complete. The realization of this probability, however, will always depend very much upon the precise character of the local formation; for, as the strata by upheaving or dislocation, may be thrown into a variety of positions, from the horizontal to the vertical,* so the difficulty of judging from any data short of actual inspection, is proportionately enhanced.

Mr. Conybeare, in speaking of the coal measures says, "the strata are generally inclined, and frequently at a very high angle, being entirely unconformable to those more horizontal beds which overlie them; they frequently also exhibit contortions as rapid and singular as those which occur in the transition slate rocks below: appearances of this kind are displayed in a manner peculiarly striking on the coasts of Bride's-bay, Pembrokeshire, near Littlehaven. It may be observed, that where the associated solid masses of limestone and sandstone are elevated in high angles, but still disposed in nearly regular planes, the more tender argillaceous beds are generally twisted, and as it were crumpled together. The Mendip Hills and adjacent collieries in Somersetshire, afford an excellent illustration of this fact, which strongly suggests the idea of a mechanical force which has elevated the more solid rocks en masse; while

* It is very uncommon to find the carboniferous strata thus highly inclined; yet at a place called the Bank, betwixt Edmonstone and Niddry, not very far from Edinburgh, about two miles south west from the sea, the strata are said to be in a perfectly vertical position; pits of a considerable depth having some years ago, been sunk in a seam of coal from top to bottom, without going into the stone on either side, which, had the working been horizontal or nearly so, would have been the roof and the floor of the coal.

the more yielding materials, giving way to its lateral pressure, have become irregularly contorted. These phenomena cannot be attributed to any internal power like crystallization; for they appear to be common to all rocks, even those most decidedly mechanical in their structure. The *faults*, or as they may be most appropriately termed, *dislocations* of the coal fields—and of which we shall treat in the next chapter—are still more irresistible evidences of their having been affected by violent mechanical convulsions subsequently to their original formation. These faults consist of fissures traversing the strata, extending often for several miles, and penetrating to a depth in very few instances ascertained; they are accompanied by a subsidence of the strata on one side of their line, or (which amounts to the same thing) an elevation of them on the other; so that it appears that the same force which has rent the rocks thus asunder, has caused one side of the fractured mass to rise, or the other to sink; it being difficult, if not impossible to say (since in either case the disjointed masses would be the same) in which direction the absolute motion has taken place. Thus the same strata are found at different levels, on opposite sides of these faults, which appear to derive their name from their baffling for a time the pursuits of the miner; they are also called *traps*, probably from a northern word signifying a step, and the elevation or subsidence of the strata is described as their *trap up or down*. The change of level occasioned by these dislocations sometimes exceeds 500 feet; whence we may infer the immense violence of the convulsion, which had power to produce motions of such vast masses to such an extent. The fissures are usually filled by clay, which has sub-

sequently filtered in, and often includes fragments disrupted from the contiguous strata; their direction usually approaches to vertical."*

It will be at once apparent, from the preceding remarks, that the same beds of coal in sections of the same basin may be found at very different depths indeed, should the field in which they occur, besides possessing great sphericity of internal structure happen to be intersected by faults or fissures; and, on the same account, it will be clear, that the details of one pit can rarely be taken as indicative of the depth to which it may be necessary to sink for coal in any particular district. It may indeed, exhibit generally the nature of the measures in any proximate portion of the same field; and also, if the dip of the strata has been ascertained, it may afford in connexion with other circumstances, good criteria for determining the probable success of an adjacent shaft. To shew the various sorts of substances through which the northern miner has to pass before he comes at the object of his efforts, the following section of the strata, south of the main dike in Montagu Main colliery, 3½ miles above Newcastle, is taken from a well written article on the subject.† The numbers in the first column on the left hand form an index, from which it will be immediately perceived, where the same strata occur; the second column contains the number of the strata; the third the names of each; and the fourth or numeral columns, express the thickness of each stratum in fathoms, yards, feet, and inches. It may also be premised concerning the five or six different classes of substances named, that whinstone is the hardest—so hard indeed, that

* Introd. Geol. Part I. p. 348. † Rees's Cyclopædia, art. Coal.

angular fragments of it will cut glass, and affording an excellent material for roads: post-stone is a very hard kind of freestone, of a fine, homogenous texture; it is this stone which has been worked for centuries for grindstones, in various situations about Newcastle, especially on Gateshead Fells, where it crops out: and also at Heworth shore, on the Durham side of the Tyne, where the most valuable quarries are situate. Sandstone is a freestone of a coarser grain than the last, and pervious to water; it does not occur in the locality of the following section, but is found under the limestone, sometimes of considerable thickness—twenty fathoms or more; metal stone is a hard argillaceous stratum, solid, compact, and interspersed with nodules of iron ore, and pyrites; shiver bleas, or black metal, as the pitmen call it, is a sort of tough shale, often interlaid with lamina of spar coal, or other matters.

		Particulars of the Strata.	Thickness of each Stratum. Fa.	Yds.	Ft.	In.
0	1	Soil	0	0	1	0
0	2	Clay	2	0	2	0
1	3	White post	0	0	2	6
0	4	*Coal*	0	0	0	4
2	5	Black metal stone	0	1	0	2
3	6	Grey post	1	1	2	0
4	7	Blue metal stone	2	1	1	0
3	8	Grey post	2	0	0	0
1	9	Strong white post	2	1	0	0
3	10	Grey post	0	1	1	0
5	11	White post, with black metal partings	5	0	0	0
3	12	Grey post	0	0	1	4
6	13	Brown post, with coal pipes	0	1	1	8
1	14	White post	2	1	0	0
7	15	Ditto, mixed with whin	0	1	0	0
		Carried over	22	0	1	0

		Particulars of the Strata.	Thickness of each Stratum. Fa.	Yds.	Ft.	In.
		Brought forward...	22	0	1	0
0	16	*Coal*	0	0	0	6
2	17	Black metal stone	4	1	0	0
8	18	Grey metal stone	4	2	0	0
9	19	Brown post, with skanny partings...	0	1	1	0
0	20	*Coal*	0	0	0	9
8	21	Grey metal stone...	1	1	2	10
10	22	*Coal* } BENWELL MAIN	0	0	1	9
11	23	Band } BENWELL MAIN	0	0	0	6
10	24	*Coal* } BENWELL MAIN	0	1	0	0
8	25	Grey metal stone	0	1	1	0
1	26	Strong white post	2	1	1	0
12	27	Whin	0	0	2	0
1	28	White post ...	1	0	2	0
0	29	*Coal*	0	0	1	8
2	30	Black metal stone	1	1	0	0
1	31	White post	3	0	0	0
2	32	Black metal stone	4	1	0	0
8	33	Grey ditto	5	0	2	4
13	34	Ditto post, with whin girdles	2	1	0	0
1	35	Strong white post	6	0	2	0
8	36	Grey metal stone	3	0	2	0
0	37	*Coal*	0	0	0	8
14	38	Post girdles	0	0	2	0
8	39	Grey metal stone	1	0	1	0
15	40	COAL, BEAUMONT SEAM	0	1	0	4
16	41	Strong white thill	0	1	0	7
1	42	Ditto, ditto, post	2	0	0	4
0	43	*Coal*	0	0	1	6
17	44	Black thill	0	0	2	4
8	45	Grey metal stone	0	0	1	2
3	46	Ditto post	0	0	2	0
8	47	Ditto metal stone	0	0	2	10
1	48	Strong white post...	0	1	0	4
0	49	*Coal*	0	0	1	3
2	50	Black metal stone	1	0	2	4
1	51	White post	0	0	1	8
18	52	Blue metal stone, with post girdles	1	0	0	0
		Carried over......	76	0	0	8

		Particulars of the Strata.	Fa.	Yds.	Ft.	In.
		Brought forward...	76	0	0	8
19	53	White post, with whin girdles......	2	0	1	9
2	54	Black metal stone....................	0	0	1	5
3	55	Grey post............................	0	0	1	2
4	56	Blue metal stone	0	1	0	0
1	57	Strong white post..........	0	0	1	3
4	58	Blue metal stone	1	0	2	1
0	59	*Coal*..................................	0	0	0	8
17	60	Black thill	0	1	0	4
18	51	Blue metal stone, with post girdles	1	0	1	0
3	62	Grey post............................	0	1	0	0
1	63	Strong white post....................	3	1	2	6
2	64	Black metal stone	0	0	0	1
20	65	COAL, LOW MAIN	0	0	2	11
8	66	Grey metal stone.....................	4	1	0	0
1	67	White post	2	1	0	0
21	68	Grey metal stone, with post girdles	1	0	0	0
19	69	White post, with whin girdles......	3	0	1	6
21	70	Grey metal stone, with post ditto...	0	1	1	0
22	71	COAL, LOW LOW MAIN*...........	0	0	2	10
8	72	Grey metal stone	0	1	2	0
1	73	White post	0	0	2	0
8	74	Grey metal stone.....................	0	0	1	8
2	75	Black metal ditto....................	0	0	0	10
8	76	Grey ditto ditto	1	0	2	6
3	77	Ditto post............................	1	0	0	6
19	78	Strong white post, with whin girdles	3	1	1	8
8	79	Grey metal stone.....................	3	0	2	6
3	80	Post ditto............................	0	0	2	0
1	81	White post	0	1	2	0
8	82	Grey metal stone	0	0	1	0
0	83	*Coal*..................................	0	0	0	6
8	84	Grey metal stone.....................	0	0	1	0
21	85	Ditto, with post girdles	3	0	2	2
0	86	*Coal*......	0	0	0	5
		Carried over......	116	1	2	3

* This is what is called, in the Hetton Colliery, the "Hutton Seam," from the name of the individual who first attempted to win the excellent coal of which it here consists, and which lies at the great depth of 147 fathoms.

	Particulars of the Strata.	Fa.	Yds.	Ft.	In.
		Thickness of each Stratum.			
	Brought forward...	116	1	2	3
8 87	Grey metal stone......................	0	0	0	4
3 88	Ditto post...............................	1	0	1	6
7 89	White ditto, mixed with whin......	2	1	0	4
8 00	Grey metal stone......................	0	0	1	0
0 91	*Coal*....................................	0	0	0	3
2 92	Grey metal stone, with post girdles	1	0	0	6
19 93	Strong white post, with whin ditto...	0	1	2	5
		122	1	2	3

In looking over the foregoing details, it is impossible not to be struck, first, with the great number of beds of various matters interstratified with the coal, amounting to nearly one hundred successive sedimentary depositions of different matters, and exhibiting various degrees of induration; second, with the thinness of the layers of coal, at the point of intersection—the Beaumont seam alone reaching a yard in thickness; while the stratum of the Low Main is under two feet, and that of Benwell Main only six inches: and, third, the depth of the section itself is remarkable, being upwards of one hundred and twenty-two fathoms, or two hundred and forty-five yards.

The above section of strata, however, is inferior in every respect to the details obtained in the sinking of a shaft at Gosforth colliery, about two miles north of Newcastle, which was finished in October, 1827. In this work, the number of strata sunk through reached one hundred and forty-one, the total depth being upwards of one hundred and eighty-eight fathoms. Forty-three seams of coal were pierced, many of them, as in the section above, very thin.

Mr. Wynch, from whose interesting paper * these particulars are derived, remarks that "the section of this mine is peculiarly interesting in a geological point of view; not only from the great number of strata passed through, but owing to the shafts by which the coal was won being sunk on the south side of the main dyke, and the coal obtained by a drift driven due north through it." This mode of coming at the coal is understood to have been adopted for the purpose of avoiding the water supposed to be accumulated in the rents and fissures of the strata towards the north, while the coal-field on the south side of the dyke, was known to have been drained by the Heaton and other engines, to the dip of the Gosforth mine.

At St. Anthony's colliery, about three miles below Newcastle, they find the High Main coal, (not distinguished in the preceding section,) at the depth of seventy-six fathoms, and measuring exactly one fathom in thickness †: at one hundred and thirty-five

* Contributions to the Geology of Northumberland and Durham, Lond. and Edin. Phil. Mag. July, 1833, p. 28.

† The High Main coal occurs in the Manor Wallsend colliery, near South Shields, at the depth of 125 fathoms: it there consists of five layers—the second and fourth consisting of bands of coal of an inferior quality, making together 1 fath. 0 feet, 5 inches. This deterioration of the stratum is called the Heworth band, as it commences in the workings of the colliery of that name. Mr. Wynch remarks that, viewers or professional men have long been aware, "that from the neighbourhood of Heworth, the High Main coal, the very best seam on the Tyne, or even in the north of England, became injured as it proceeded in a south easterly direction, by being intermixed by a band of coal of inferior quality with an admixture of strong matter and iron pyrites." Owing to the intervention of the band above named, an opinion was long prevalent that no mine could be worked with profit near or under the magnesian limestone formation. "I am not aware," adds Mr. Wynch, "that the limestone was ever thought to be the direct cause of rendering the coal of inferior quality: but one thing was certain, that whenever the collieries on the south side of the Tyne extended their workings in the direction of the limestone hills, the Heworth band was sure to injure the coal."

fathoms the Low Main coal is found upwards of a fathom thick. Jarrow, about five miles from the mouth of the Tyne, and on its southern side, is the spot beneath which the bituminous beds in the coal-measures in this neighbourhood are found at their greatest depth; the High Main stratum is 960 feet below the grass at Jarrow, and rises on all sides; but as the dip of the strata (which averages one inch in twenty) is not uniform in every part of the surrounding district, that bed does not rise to the surface at equal distances around that place. Mr. Conybeare, from whose statement these particulars are derived, goes on to remark that as the High Main coal rises to the surface of the alluvial soil, around Jarrow, we may conclude that the beds of it above and below the High Main arise also at a distance from it, proportionate to their depth beneath it. These beds, and the other strata composing the coal measures, are not every where of uniform thickness, but occasionally enlarge or contract so greatly, that it is only by an extensive comparison of the whole series, that any certainty is arrived at concerning that general uniformity of stratification which is known to exist.*

Mr. Bald has given in the Memoirs of the Wernerian Society, a section, and Messrs. Conybeare and Phillips, in their Introduction to Geology, a table of the coal and associated beds, as occurring at Dudley, in Staffordshire. From this table we see that the beds distinguished by different names in this coal

* The difficulty of identifying the various coal seams north and south of the great dyke or dislocation of the northern field, is admitted by all writers on the subject: indeed, such identity as regards the minor seams especially, is still "a problem unresolved." An interesting Synopsis of the principal Coal Seams on the Tyne and Wear (18 in number) is given by Mr. Buddle, in Trans. Nat. Hist. Soc. Northum. i. 219.

formation, but consisting most of sandstone, and a sort of clay shale, provincially called *clunch*, amount to sixty-five, and that its whole thickness is 313 yards, 1 foot, and 3 inches, or about 156 fathoms, somewhat more than the depth of the High Main coal at Jarrow. There is another particular, however, in which the South Staffordshire collieries differ most strikingly from those on the Tyne: the main coal, which is the great object of the colliers in the former country, is about 60½ fathoms below the surface in the neighbourhood of Dudley, *ten yards in thickness:* about thirty yards below it, lies another bed *five yards thick.* The beds of coal are eleven in number—five above, and five below the main coal; none of the former are considered worth working. The ten-yard, or main coal, which is of a slaty texture, consists, in fact, of thirteen different laminæ, which were thus distinguished in Dr. Plott's time—some of the terms being still in use about Dudley:—

		Ft.	In.
1	Roof floor, or top floor	4	0
2	After a parting of four inches of soft, dark earth—top slipper, or over slipper	2	2
3	Jays	2	0
	White stone *(Patchel)*	0	1
4	Lambs	1	0
5	Tough Kitts, or heath	1	6
6	Benches	1	6
7	Brassils, or corns	1	6
	Foot coal parting (sometimes only.)		
	Thickness	13	9
8	Foot coal, or bottom slipper	1	8
	*John coal parting......*1 *inch.*		
9	John coal, or slips, or veins	3	0
	Hard stone, 10 *inches or less.*		
10	Stone coal, or long coal	4	0
	Carried over	8	8

		Ft.	In.
	Brought forward...	8	8
11	Sawyer, or springs	1	6
12	Slipper	2	6
	Humphrey parting.		
13	Humphreys, or bottom bench—or Omfray floor	2	3
		14	11
		13	9
	Total Main Coal	28	8

Of these different beds, the upper one, or roof floor, is generally left to support the earth and clunch above it; the second, third, and fourth beds, which together are called the white coal, are reckoned the best for chamber fires. Next to them in goodness are reckoned the eleventh and twelfth beds; after them, some the eighth, ninth, and tenth. The toughs and benches are preferred for making cokes; and are generally reserved for the furnaces: they do not kindle and flame so vividly as the foregoing, but they give a more durable and stronger heat. The part of the brassil measure which contains pyrites, is generally laid aside, or used for burning bricks or lime: the humphrey being the lowest portion, is cut away to let those above fall down, and, therefore, most of it is reduced to small coal or slack.

The beds dip towards the south, and rise towards the north; so that at Bilston the main coal crops out and disappears altogether.

The strata in the mines at Bradley, near Bilston, are noted by Pitt as follows:—

No.	Strata.	Depth. Ft.	In.
1	Surface soil	1	6
2	Clay and ratch	9	0
	Carried over	10	6

No.	Strata.	Depth. Ft.	In.
	Brought forward...	10	6
3	Clunch	2	6
4	Ironstone	0	2½
5	Clunch	2	0
6	Ironstone	0	2
7	Soft clay	0	2
8	Dark batty clunch	3	0
9	Gray jointy rock	4	0
10	Ironstone	0	1½
11	Rock-binds with ironstone	4	0
12	Soft parting	0	1
13	Strong black rock	4	0
14	Dark clunch	7	0
15	Ironstone	0	5
16	Dark clunch, with ironstone	5	0
17	Ditto, fuller of ironstone	0	10
18	Soft clay	1	8
19	Batt	2	3
20	Brooch coal	3	6
21	Fire clay	0	4
22	Black ironstone	0	1
23	Black earth	1	6
24	Ironstone	0	2
25	Black earth and ironstone	1	6
26	Ironstone	1	5
27	Rock-binds, with ironstone	10	0
28	Dark earth, with ironstone	6	0
29	Rock-binds, with ironstone	9	0
30	Peldon	4	0
31	Grey rock	23	0
32	Dark clunch	2	0
	To the Main Coal	110	5
33	White coal	3	0
34	Tow (or tough) coal	2	3
35	Benches and brassils	4	6
36	Foot coal	2	3
37	Slip batt	2	3
	Carried over......	14	3

carried more than one thousand yards under the sea, and about six hundred feet below its bottom, the strata still dipping westward, at a considerable angle.*

The following is an exact account of the different beds of coal, their depth below the surface, distance between each other, and thickness of each bed, in the old King pit, situated about 700 yards to the west of Whitehaven, near the sea shore. The top of this pit is elevated twenty-seven fathoms, one yard, and seven inches, above the level of the sea:—

	Depth below the surface.		Distance between the beds.		Thickness of each bed.		Remarks.
	Fath.	Yds.	Fath.	Yds.	Ft.	In.	
1st bed...	15	1	15	1	1	10	An inferior kind of coal.
2nd bed..	27	1	12	0	1	6	Ditto, yet saleable.

Between the second and third beds are seven thin seams of coal.

3rd bed..	81	0	53	1	4	2	Mixed with several impurities.

Then follow three thin seams.

4th bed..	101	0	20	0	7	6	Some layers are very pure, others much mixed with ferruginous and other earths.

A thin bed of coal, after which

5th bed..	121	0	20	0	12	0	Very fine coal.

Then follow four thin seams.

6th bed..	147	0	26	0	2	0	Ditto.

After three thin seams, occurs the

7th bed..	165	1	18	1	6	1	A little inferior in quality, but yet very inflammable.†

* Thwaite Pit, in the Howgill colliery, which was sunk 149 fathoms to the sixth bed of coal, was formerly supposed to be the deepest pit in England.

† Brownrigg's Literary Life, p. 125.

At Whingill, north-east of Whitehaven, the beds are from four to ten feet in thickness, and dip one yard in ten: in the depth of 165 fathoms they work seven large beds, and have noticed eighteen thin ones. At Preston How, they cut fourteen beds of coal before they met with one at all considerable, but the fifteenth bed proved more than five feet in thickness; and the seventeenth, separated from the former by twenty-four beds of slate, ironstone, sandstone, and one thin seam of coal was nearly eight feet in thickness.

There are some considerable mines in Warwickshire, at Griff and Bedworth; at the former place, four beds of coal are worked, the depth of the first being 117 yards, and the principal seam nine feet in thickness; the works of the latter place are on the same bed, but here the first and second coal seams of Griff run together, and constitute one five-yard seam.

A section of the Ashby coal-field, at the village of Donisthorpe, as given by Mr. Mammett, presents us with ninety-three alternations of strata included in a depth of 475 feet, or nearly 79 fathoms. There are five beds of coal of different qualities, and averaging about three feet in thickness, occurring at intervals above the "main" and "nether" coals, which are in contact, and together fourteen feet in thickness. At Moira colliery on Ashby Wolds, the floor of the main coal lies at the depth of 744 feet; and in the Hastings' pit, more towards the middle of the basin, the main seam, of which the upper half alone is at present wrought, reposes on a stratum of fire clay about 1000 feet below the surface. The beds alternating with the coal, are mostly in different sandstones, ironstone, bind in different stages of in-

duration, and a valuable fire clay. About Burslem, in the north of Staffordshire, where several pits are wrought in what is sometimes called the Pottery coal field—thirty-beds of coal have been noticed; they are, in general, from about three to ten feet in thickness. One of the beds, forming part of the South Lancashire field, and worked near Manchester, is a four feet coal.

It would be improper to pass over without more particular notice, the measures of the great Yorkshire and Derbyshire coal field, which, in the opinion of Mr. Conybeare, rivals or even surpasses in importance that of Northumberland, with which it so closely agrees in the direction, inclination, and character of its strata, that it has been considered a re-emergence of the same beds from beneath the covering of magnesian limestone, which conceals them through so long an interval.*

According to Mr. Farey,† the carboniferous group of this extensive and important district, consists of about twenty gritstone rocks of different kinds, including within their planes of parallelism, at fewest twelve seams of workable coal, but probably more, with their accompanying shales and beds of nodular or other ironstone. The same author has given a list of about 500 collieries in work upon these seams in 1811, or that had been worked there in former years. Those pits particularised were, for the most part, situated in Derbyshire or Yorkshire; many of them had been carried on for a long period antecedent to the above date, and several are not yet abandoned: of course, a considerable number of new works have

* Introd. Geol., p. 378.

† Agricultural Survey of Derbyshire, vol. i. 181.

been established in this vast field, during the intervening twenty years. Of the pits in the list adverted to, of which the seams into which they were sunk are distinguished, the first seam contained 59 pits; the second, 77: the third, 25; the fourth, 5; the fifth, 3; the sixth, 1; the seventh, 6; the eighth, 28; the ninth, 23; the tenth, 20; the eleventh, 8; and the twelfth, 24 pits. As the measures dip mostly from west to east, and as the foregoing numbers, indicative of succession of strata, are reckoned from the lowest to those above, the former, or lowest members alternate with the millstone grit forming the bold mountain scenery west of Sheffield, while the latter pass beneath the magnesian limestone which extends in a lofty ridge to the east of that town.

The vicinity of Rotherham is distinguished by a remarkable and thick soft salmon-coloured grit stone, conspicuously reddening the arable soil, and which Mr. Farey supposed to be identical with number sixteen of his series. The principal vicinal seams of coal, at present worked for the supply of the important manufacturing town of Sheffield, in addition to pits at Birley Moor, in the tenth seam above indicated, are five in number, lying between the before mentioned salmon-coloured grit, or as it is locally termed "Rotherham red rock," and the Wortley sandstone: the latter, overlying another series of beds associated with the millstone grit above mentioned. Taking the strata in the descending order, the first to be mentioned is the Tinsley Park coal, which consists of an upper seam four feet in thickness; and at a depth of 13 fathoms lower down, occurs another seam 27 inches thick, of dull stony aspect, very hard, and called from the use to which it is largely applied,

Furnace coal. About 20 fathoms still lower we come to what is locally termed the High Hazles seam, consisting of seven layers of different appearance and qualities, and making together a thickness of about a yard and a quarter. Fifty fathoms below the bottom of the last mentioned, lies the Handsworth seam, four feet six inches in thickness, and exhibiting eight distinct laminæ, technically known as tops, bright, best bright, top hards, dead bed, black hards, spire hards, and pricking coal: the four varieties preceding the last named, are largely in demand by the furnace men employed in converting steel. The lowest portion of this seam, where wrought at Attercliffe, yields a vast quantity of the variety called cannel coal, being of a fine homogeneous texture, excellently adapted to the purposes of the turner, for which it has been fetched to Birmingham; and also affording on distillation abundance of gas,—Sheffield having at one time been exclusively illuminated by the gas evolved from it. One hundred fathoms below Handsworth bed, we come to the Manor seam, five feet in thickness, and divided into fifteen distinct layers, including two of soil. Under this, after a barren interval of fifty-five fathoms, comes what is called the Sheffield bed, six feet in thickness, and presenting six or eight varieties of coal, some of them abounding with pyrites, and occasionally producing near the top a beautiful and compact kind of cannel, or as it is called in Yorkshire, branch coal. The measures dip rapidly towards the east, the basset or outcrop of most of the seams being traceable in the vicinity of the town; two or three acres of the last mentioned coal being, as elsewhere noticed, denuded in one part by the formation of new streets.

In 1832, Mr. Phillips, one of the Secretaries of the British Association, communicated to the Yorkshire Philosophical Society, a paper on the lower, or ganister coal series of Yorkshire, containing some remarks on the fossil productions of the strata, and which have been noticed in a previous chapter. The writer defines this series by saying that it is included between the millstone grit of Bramley beneath, and the flagstone of Elland above, having a thickness of about 120 or 150 yards, and inclosing, near the bottom two thin seams of coal, one or both of them workable, and several other layers scattered through the mass, too thin to be worth working. The most regular and continuous bearing of all these coal seams, is stated to be, in a few places, of the thickness of 27 or 30 inches, but is generally only about 16 inches. The coal here alluded to is that occurring in the second and third of Farey's seams indicated above: it is worked at several places near Leeds, Bradford, Halifax, and Sheffield. The following is a section of Swan Banks Colliery, near Halifax, as furnished to Mr. Phillips, by C. Rawson, Esq. of the latter place; and is said to present a good idea of the general character of the whole of this lowest coal series.

	Yds.	Ft.	In.
Ragstone, (the lower part of the Elland flagstone)	27	0	0
Black shale	40	0	0
Coal (80 yards band coal)	0	0	6
Rag	4	0	0
Black shale	28	0	0
Coal (48 yards band coal)	0	0	11
Grey shale	0	2	0
Black shale	7	1	3
Dirt band (black tough clay)	0	0	3

	Yds.	Ft.	In.
Black shale	4	1	6
Coal (36 yards coal band)	0	0	7
Galliard	1	0	0
Black shale	12	0	0
Rag and shale	13	0	0
Black shale	7	0	0
Shale and ironstone (called hard band), flat baum pots	0	2	3
Grey shale (called White Earth), with small round baum pots containing *Ostreæ ?*	1	0	0
Concretions (called baum Pots), with Ammonites, &c.	0	1	0
Black shale (called Moon Bassett), with Pectens	0	1	0
Coal (the hard band coal) worked	0	2	3
Seatstone	0	1	0
Seat earth (white clay), with vegetable fossils	2	0	0
Grey shale	5	0	0
Black shale	4	1	6
Coal (middle band coal)	0	0	10
Middle band stone	1	1	0
Black shale	8	0	0
Layer of fresh water shells (*Unio*)	0	1	0
Black shale	3	1	0
Ironstone	0	0	3
Black shale	0	0	8
Coal (the soft bed coal) workable	0	1	5
Upper millstone grit, on which Halifax stands.			

In the above, and another section through similar substances, adduced by Mr. Phillips, "we observe," says this intelligent geologist, "besides the very remarkable layers of marine shells*, several occur-

* The undoubted occurrence of marine shells has been complacently appealed to by those who incline to the notion of a diluvial rather than a lacustrine origin of our coal deposits. So far, however, as the presence of characteristic testacea goes, the evidence, if not equal, is not in favour of the former theory: for example, at a late annual meeting of the Geological Society, Mr. Prestwick described a heterogenous assemblage of plants and shells, both of fresh and salt-water species, as occurring in the carboniferous strata of Coalbrooke Dale; and on the same authority, that Mr. Murchisson has found at Ponterburg and elsewhere on the opposite side of the Severn,

rences of a peculiar hard siliceous sandstone, called Galliard, Ganister, or Seatstone (according to local custom, or slight differences), which in fact is the same thing as the 'crowstone' of the mountain limestone district in the north-west of Yorkshire, and like that contains in abundance the remains of plants, particularly of the genus *Stigmaria*, Brong. By the extreme abundance of plants of this kind, indeed, the galliard beds may almost always be recognised throughout their range in Yorkshire. This stone, in some cases, forms the floor or sill of the coal seams, —a circumstance never observed in the upper coal strata, amongst which, indeed, galliard never occurs in its true character. Hence this whole group of strata may be appropriately called the Galliard or Ganister coal series." *

The coal measures of the great South Welsh basin are on a magnificent scale, both as to extent and thickness: the depth at which the miner reaches the different strata varies greatly, depending upon the situation of the pit. The principal part of the coal lies under Glamorganshire, and here the strata are found from 5 fathoms to 6 or 700 fathoms deep; though in 1806, Mr. Martin states, it had not been found necessary to pursue these strata deeper than about 80 fathoms. There are 12 distinct seams of coal in this immense mineral depository, from 3 feet to 9 feet thick each; which together make 70½ feet:

a band of compact limestone between two beds of coal, "resembling the lacustrine limestone of central France, and containing fresh-water shells." Some authors, in order to account for the mixture of these different shells, have had recourse to the gratuitous notion of a series of reciprocating inundations of salt and fresh water: ingenious experiments have likewise been instituted, to shew the possibility of habituating marine testacea to live in fresh water, and those of our lakes to exist in the sea.

* Phil. Mag. and Journ. of Science, Nov. 1832. p. 352.

and there are 11 more, from 18 inches to 3 feet, which make 24¼ feet; besides a number of smaller seams from 12 to 18 inches, and from 6 to 12 inches in thickness, not calculated upon. The average length and breadth of the different strata of coal are computed at about 1000 square miles, containing 95 feet of coal in 23 distinct strata, which will produce, in the common way of working, 100,000 tons per acre, or 64,000,000 tons per square mile. The coal at the east end of the basin, from Pontypool to Hirwain Furnace, is of a coking quality; from thence to Bride's Bay, at the opposite extremity, the strata yield stone-coal, or culm; on the south side of the basin, the coals are principally of a bituminous, or binding quality.*

Some of the coal fields of Scotland contain seams of surprising thickness: in Clackmannanshire, where exists the north-east boundary of the Scottish coal district, the beds alternate with a great variety of other strata. In the main coal field, the formation has been examined to the depth of 704 feet; with some exceptions, the stratification exhibits great regularity, the layers being in many instances very thin. There are 142 alternations of strata, including 24 beds of coal; these beds or seams are from two inches to five feet in thickness, six of them being three feet or upwards, amounting together to 59 feet 4 inches. The principal bed is at the depth of 120 yards; and the coal is of the cubical and slaty varieties; sometimes both sorts occurring together, but no blind or glance coal. It is all what is called *open burning* coal, having little or no tendency to cake. In the Johnstone coal field, near Paisley, the

* Phil. Trans. vol. 96. p. 345.

upper stratum of rock is compact greenstone, above 100 feet in thickness, not in conforming position with the coal strata, but overlying; then a few fathoms of soft sandstone and slate-clay alternating and uncommonly soft. Under this, in one place, there are no fewer than ten beds of coal lying one immediately over the other, with a few divisions of dark coloured indurated clay. These beds of coal are in thickness, no less than 100 feet: this, Mr. Bald remarks, is a mass of combustible matter in the form of coal, probably unparalleled in the world. The largest seam of the Tranent collieries, near Haddington, is said to be nine feet thick.

Of the coal strata, in Ireland, we have few particulars. Lord Greenock* has pointed out that the appearance of the carboniferous series in Arran, and at Cambelton, in Kintyre, as well as the indications of its existence at Ballycastle, and other places on the Irish coast, within the prolongation of the lines above named, as indicating the Scottish lowland coal district, seems fully to establish the geological connection in this, as well as in most other respects, between the west of Scotland and the north-west of Ireland. In the Dromagh colliery, in the Munster district, as we learn from Mr. Griffith, all the beds hitherto discovered have been successively and successfully wrought: four of these beds incline on each other at no greater distance than 200 yards. The first is a three feet stone coal, and is the leading bed. All the faults, checks, and dislocations similar to those which are discoverable in this bed, are in general to be encountered in the other three; the names of the four beds are, the *coal bed;* this lies

* Before the Royal Society of Edinburgh, December, 1834; Jameson's Journal, April, 1835, p. 384.

further to the north; the *rock coal*, so called from its being comparatively of a harder quality than the other beds; the *bulk bed*, so called from its contents being found in large masses or bulks; and *Bath's bed*, so called from the name of a celebrated English miner, by whom it had been many years ago discovered and worked; the coal bed consists of three-feet solid coal, and is not sulphureous; the rock coal is nearly of the same thickness with the leading bed, but is very sulphureous, and having the soundest roof is the most easily wrought. The other beds are of the culm species, but of peculiar strength: each barrel of culm having been ascertained to burn from nine to ten barrels of the lime of the district. The bulk bed forms, as already stated, immense masses of culm, in which the miners have frequently been unable to retain the ordinary direction of roof and seat. No work in this district has been carried deeper than eighty yards, as in the Dromagh colliery, where the coal is heavily watered, and the consequent expensiveness of working is very considerable.

The occurrence of the argillaceous carbonate of Iron, either in the form of nodules or of continuous beds, in immediate connexion with the coal seams, is a circumstance of immense importance, as lying at the foundation of the manufacturing superiority of this country. In South Wales, Staffordshire, Yorkshire, and other parts of the United Kingdom, particularly in Scotland, the proximate abundance of coal and ironstone has led to the establishment of those immense smelting works, upon the success or deterioration of which such such vast outlays of capital, and the industry and happiness of so many thousands of individuals depend.

It is not necessary in a work, the object of which

is not statistical, to particularise the succession and locality of the ironstone strata, as for the most part, they are found wherever the coal formation occurs. In some cases, the one is sparingly, in others most abundantly interspersed in the carbonaceous group. In the great South Welsh coal field, immediately upon the millstone grit, which overlies a mass of mountain limestone, 85 fathoms in aggregate thickness, reposes a thick series of shale beds, alternating with thin bands of hard sandstone. The first visible or lowest seam of coal, occurring in this shale is two inches thick: a few fathoms above this seam there occur from fourteen to sixteen beds of ironstone, nine of which are visible at the surface; they are embedded in shale, and occupy a perpendicular depth of 13 to 14 fathoms, continuing their range to the eastward; these are the principal beds from which the supply of ore for the Welsh iron works is procured. According to Mr. Forster,* these ores yield about 26 per cent. of iron; there are several other beds interstratified with the different seams of stone coal.

The mines in the Forest of Dean furnish a curious stalactite, rich in iron, and termed *brush ore*, from its being found hanging from the tops of caverns in striæ resembling a brush. The Lancashire ore is very ponderous, of a lamellated texture, and of a dark shining purple or bluish colour. The rich Cumberland ore resembles in colour the last mentioned, while its polished surface seems to consist of congeries of various sized bubbles, as if the mass had once been in a state of ebullition.† Besides the

* Observations on South Welsh Coal Basin in *Trans. Nat. Hist. Soc. Newcastle*, vol. i. p. 100, a highly interesting account.

† Lardner's Cab. Cyclopædia, "Manufactures in Metal," vol. i. p. 33. A very elaborate and interesting investigation of the composition of the

valuable deposits of argillaceous iron ore which, existing in immediate contact with most excellent coal, have given to Wednesbury so distinguished a place among the iron manufactories of this kingdom, may be added the occurrence of a peculiar species of the ore called Blond metal, and which after being smelted, is used for the making of a variety of tools. The coal in this neighbourhood, is reckoned the best in the kingdom for the smith's forge: it is found in beds of from three to fourteen feet in thickness. Wolverhampton, another extensive manufacturing town in this county, owes its celebrity to the favourable position in which it is placed with reference to subterranean riches, and inland navigation. Situated nearly in the centre of the kingdom, in the midst of the most productive coal and iron mines, and having a free and easy access to the great rivers Thames, Severn, Trent, and Mersey, by means of the different canals which surround it, every opportunity is afforded of conveying and receiving materials and merchandise.*

argillaceous carbonates of iron, from which by far the greatest proportion of our British iron is smelted, is printed in Brewster's Edinburgh Journal for 1827—8, from the pen of Dr. Colquhoun.

* Pitt's Staffordshire, p. 171.

CHAPTER VIII.

DISLOCATIONS OF STRATA.

Common occurrence of fissured strata—Longmire's theory of veins, dykes, rents, slips, &c.—How characterised—Up-throw and down-throw dykes—Section of fractured coal measures at Jarrow—Enormous disturbances produced by faults—Great trap dyke of Yorkshire and Durham—The ninety-fathom dyke of Northumberland—The seventy-yards Whin dyke—The "great Derbyshire denudation" of Farey—Nonconformity of overlying and subjacent masses—Supposed igneous origin of trap or basaltic dykes—Advantages of those dislocations misnamed "faults"—Professor Buckland's observations.

ALTHOUGH several allusions have already been made to the subject of this Chapter, it is of too interesting a nature, in every point of view, to be merged in merely incidental notices. From what has been said already, it will have appeared, that besides the divisions of strata into different substances, often repeated after certain intervals, and generally extending in parallel series, variously inclined through the coal measures, there are certain fissures or fractures often nearly vertical, stretching through the whole

mass in a very singular manner, and betokening a violent upheaving or subsidence, and consequent separation of formerly continuous or adjacent portions. These rents, which every one must have remarked on a small scale in almost every stone quarry, and which traverse the coal formation in every district, are not only striking objects of inquiry to the geologist, but of vast importance in mining operations; and although generally termed *faults*, they are in reality of immense benefit in our colliery operations.

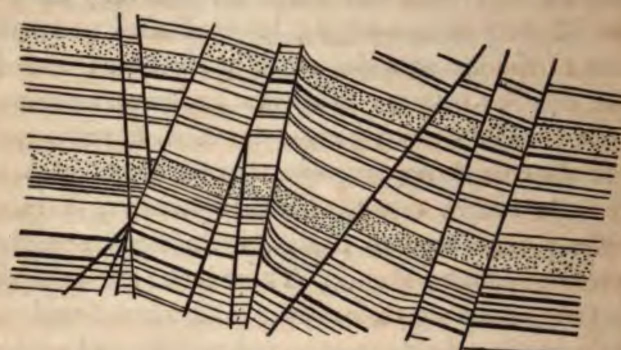
In the "Annals of Philosophy" for the year 1815, there is an elaborate essay on the shapes, dimensions, and positions of the spaces in the earth which are called Rents, and the arrangement of the matter in them, by Mr. J. B. Longmire, of Kendal. The object of the writer is to prove that metallic veins, dykes, slips, and other rents, in the internal part of the earth, were formed when it was passing from a fluid to a solid state, and are owing to an unequal contraction of its matter; and that the phenomena of stratification and formations, in some points of view, as well as the features of the earth at its surface, are effects of the same cause. Most of these fissures, particularly those supposed to have been the earliest formed, appear to have been filled by some of the matter at their sides being forced into them while yet in a fluid state, by the pressure of the superincumbent mass: others appear to have been filled with matter that, at a later period, entered them either in a fluid state, as greenstone, basalt, &c., or in a solid state, as gravel, sand, and clay, generally mingled with fragments of the adjoining strata. The mineralogical compounds of the first class, varying in character from the distinct granitoidal crystalliza-

tion of their original base, to the compact basalt, exhibiting but obscure traces of granular texture, are frequently met with in these subterranean clefts, as well as connecting with the various strata in overlying or proximate masses, and sometimes even intervening the earth. These masses, denominated by geologists *trap rocks,* and which are generally allowed to be of volcanic origin, have afforded no small portion of the ammunition which has been expended in the disputes between those who assign an aqueous, and those who contend for the igneous, formation of the strata composing the present crust of our planet.

But, to return to rents: these spaces are divided by Mr. Longmire into ovalar, cylindrical, straight and bended-tabular shapes. These latter are the most ordinarily occurring dislocations, and when found to contain earthy tabular masses, and metallic and earthy crystals, are known by the appellations of slips, dykes, shifts, lodes, troubles, and faults. They are denominated slips, by some geological writers, because the strata on one of their sides have slipped from those on the other, and fallen below them. They are known at Whitehaven and elsewhere by the name of dykes, because they divide the seams, or bands of coal, as they are sometimes called, into fields; and they are called *up-throw* or *down-throw* dykes, as the edge of the strata appears to an observer to be higher or lower in regard to his own position. They are called *shifts* in some parts of England and Scotland, as they are considered by the majority of miners in these parts to have shifted the strata on their sides. In Cornwall, they are denominated cross lodes, or, when round or ovalar, pipe veins; and in some parts of the kingdom they are called

troubles, or *faults*, from their troubling, or putting to fault, the pitmen; or the latter term may have arisen from the supposition that the rents have been occasioned from something faulty in the aggregation of the matter of the rocks themselves. The subjoined diagram, which will strikingly illustrate the disloca-

Fig. 18.



tions in question, is from a splendid section, on a large scale, presented by Mr. Buddle to the Natural History Society of Newcastle-upon-Tyne, in which neighbourhood (at Jarrow) the portion of coal measures thus singularly broken up, occurs.

We mentioned in the preceding Chapter, that the change of level in the same strata sometimes exceeds 500 feet. This amazing dislocation, indeed, appears almost trifling, when compared with the great south slip in the Clackmannanshire coal field, which, according to Mr. Bald, throws down the strata no less than 1230 feet; the north slip in the same field throwing it down 700 feet. These fissures extend from the surface of the strata, or rock-head, sometimes to an unknown depth; they vary in width from a fraction of an inch to four or five yards, or more. Their descent is sometimes nearly vertical, but more

commonly they are oblique; the north slip above mentioned makes an angle with the horizon of about 60 degrees. The Saltom north dyke, near Whitehaven, has been ascertained to descend more than 55 yards in an angular direction. It may be interesting to remark, that, however naturally it might have been expected that where subterranean disturbances had been effected on so vast a scale, the surface of the ground should exhibit some corresponding indications, this is found not to be the case; and even immense beds of marl, limestone, &c. sometimes overlie these dislocated tracts, presenting no traces of fracture. Indeed, not only do the alluvial and solid coverings often bear no relation to the dip or disruption of the subjacent strata; but it frequently happens that the ground over some very considerable dislocations appears remarkably level and undisturbed.

Although *up-thrown* and *down-thrown*, as being relative terms, convey no precise idea when used generally, yet there is a sense in which they are practically understood by pitmen; for with regard to slips in coal fields, we find there is a general law connected with them as to the position of the dislocated strata. Suppose a slip is met with in the course of working horizontally in a mine—if, when looking at it, the vertical line of the fissure forms an acute angle with the line of the pavement upon which the observer stands, we are certain that the strata are thrown downwards upon the other side of the slip. On the contrary, if the angle formed by the two lines above mentioned is obtuse, we are certain the strata are thrown upwards on the other side of the fissure. When the angle is 90°, or a right angle, it is altogether uncertain whether the dislocation throws up or

down on the opposite side of the slip. When what are commonly called dykes intersect the strata, they generally only separate the portions, without any dislocation either up or down; so that if a coal seam is intercepted by a dyke, it is found again, by running a gallery directly forward, corresponding to the angle or inclination of the coal with the horizon.*

It is justly observed by the author of an interesting work,† that one of the most remarkable features on a geological map of England is the line of the great trap dyke from beyond Cockfield Fell, in Durham, to the Smeaton Moors in Yorkshire, a distance of sixty miles, inclosing throughout its length a subterranean wall of basalt varying from thirty to sixty feet thick. This dyke, the longest known, resembles in composition and appearance, and is supposed to be united towards the west with, the "Great Whin Sill," or basaltic formation of Upper Teesdale.

There are several considerable dislocations of strata in the coal fields of Northumberland and Durham; the most celebrated of these is called the Main, or Great Dyke, or Ninety-fathom Dyke. The latter name has been given to it because the beds on the northern side are 90 fathoms lower than those on the southern side of it; its underlie is inconsiderable. In some places its width is not great; but in Montagu colliery it is 22 yards wide, and is filled with hard and soft sandstone. This dyke is visible in a quarry at Cullercotes, a little to the north of Tynemouth; from whence it traverses the coal strata in the direction of N.N.E. and S.S.W. past Crawcrook, a distance of sixteen miles, and probably passes into the formations underlying the coal measures. From

* Memoirs Wern. Soc. vol. iii. p. 134. † Phillips' Geol. Yorks. p. 179.

the southern side of this dyke, two others branch off, one to the S.E., the other to the S.W. The latter is called from its breadth the Seventy-yard Dyke, and, like the main one, is filled by a body of hard and soft sandstone: it intersects the upper seam of coal, which it appears is not thrown out of its level by the interruption. The seam, however, decreases in thickness from the distance of 15 or 16 yards; there the coal first becomes sooty, and at length assumes the appearance of coke—a phenomena unknown, except in the vicinity of basaltic dykes. The south-eastern branch is only 20 yards in breadth.*

Fig. 19.

The above diagram exhibits a section of the great slip as it cuts a portion of the coal field near Newcastle; and also of the intersecting Whin Dyke, the central portion of which consists of basalt, sixteen feet in thickness.

A A. The Ninety-fathom Dyke, of unknown depth.

B B B. The Whin Dyke, extending underground in an undulating course, from Coley Hill, G, in a N.W. direction to Simondside, towards the S.E., beyond the right extremity of the diagram, a distance of about eleven miles.

C C. The High Main coal.—D D. The Low Main coal.—E E. The Beaumont seam.—F F F. Level of the river Tyne.—H. Benwell colliery.—K. Newcastle town Moor.

Mr. Farey has described† a striking arrangement

* Introd. Geol. part i., p. 376. † Phil. Trans. 1811. p. 242.

of faults, extending into the counties of Derby, Stafford, Nottingham, Chester, and York, and surrounding in its largest scope an immense tract, within which two other portions are successively still farther raised, the innermost immediately surrounding the town of Bakewell, which indeed is situate towards the centre of this singularly lifted district. As the strata thus raised have also become, owing to various causes, completely exposed or uncovered in high situations, the whole tract, from the county in which the greater part of it lies, has been designated by Mr. Farey "the great Derbyshire denudation." This phenomenon, let it be remembered, presents no anomaly as viewed in connection with the statement previously made relative to the non-coincidence of the alluvial covering with the displacement of subjacent strata. In Somersetshire, coal measures, highly inclined, lie beneath, and are concealed by, horizontal beds of red marl; and in the same country great faults, which elevate the coal seams seventy yards, produce not an inch of displacement in the superincumbent matter. And examples are well known in Yorkshire, where inclined coal measures are covered by nearly horizontal magnesian limestone, which is unbroken by the vast dykes and faults in the subjacent coal.* As might be expected, the basaltic rock, when occupying these fissures, has, on account of its extreme hardness, been less wasted by diluvial and atmospherical changes, than the softer strata which bound it; and, therefore, in some places it appears above them in a long crust or ridge, or ranges along the moors like an ancient military road, and even in some places stands up in a lofty wall.†

* Phillips' Geology of Yorkshire, p. 15. † Ibid.

The contents of these fissures, as already noticed, comprise not only mixed matters evidently the detritus of the strata through which they pass, but sandstone, and the more peculiar formations of basalt and toadstone, to which it seems difficult to deny an igneous origin, or to doubt that it has been ejected from below, or forcibly intruded into the strata.* It must be added, however, that these latter substances are not unfrequently accompanied in the coal measures with very unequivocal traces of the operation of fire. In most instances the edges of strata, where the faults cut them, are affected in density at least, and generally the rocks, or those portions of them adjacent to trap dykes, have assumed a greater degree of induration; loose grits have passed into compact quartz rock, and clay or shale into flinty slate, or in some instances into a compact substance called porcelain Jasper. The coal is found completely charred, or converted into coke, of an ash-grey colour, and porous, having the fracture, and in other respects resembling that produced by distillation in close vessels at the gas and coal-tar works. In Northumberland, one working exhibits the coal thus affected at a spot where it is 18 feet thick on one side, and 9 feet thick

* As the Whin Dyke, previously described, does not pass through the Beaumont coal seam, Mr. Buddle, from whom the particulars are derived, considers that this and other facts shew it to be an exception to the generally received opinion, that whin dykes have been formed by the basalt in a state of fusion having always been forced upward through the fissures, in the stratification from below, and that they extend to an indefinite depth. It is also doubtful whether those basaltic fissures, which occur in various parts of the Newcastle coal field, run through the strata in uninterrupted and continuous lines. *Trans. Nat. Hist. Soc. Newcastle.* 1830.—Mr. Hutton considers High Teesdale to mark, as it were, a centre of volcanic action, from a crater in which the basalt of the great dykes of Durham and Yorkshire may have flowed, as they appear to spring from hence as from a focus, which had continued in activity at different periods up to one even beyond the consolidation of the oolitic series. *Trans. Nat. Hist. Soc. Newcastle*, ii. 212.

on the other side of the dyke, which is here filled with a vein of basalt 13 feet thick. At Cockfield Fell, in Yorkshire, where the coal near the dyke is converted into a black substance like concreted soot, "in the stratum above the cinder a great deal of sulphur is sometimes found, in angular forms, of a bright yellow colour, and very beautiful." It may be farther remarked, that the sandstone adjoining this substance is found changed to some depth to a brick-red colour; and even limestone is often rendered highly crystalline, and unfit for lime, when in the vicinity of this rock.

"Dykes," says Mr. Conybeare, "are an endless source of difficulty and expense to the coal-owner, throwing the seams out of their levels, and filling the mines with water and fire-damp. At the same time they are not without their use; when veins are filled, as is often the case, with stiff clay, numerous springs are dammed up, and brought to the surface; and by means of those dykes which throw down the strata, valuable beds of coal are preserved within the field, which would otherwise have cropped out, and been lost altogether. Several valuable beds of coal would not now have existed in the country north of the main dyke [above described], but for the general depression of the beds occasioned by that chasm."*

We shall close the present Chapter by an eloquent passage from the Inaugural Lecture published by Professor Buckland, in which that learned geologist adverts in a striking manner to the beneficial bearing in the economy of the earth, of those numerous dislocations so generally misnamed *faults*, of which we have been treating. After adducing some of those

* Introd. Geol. part i. p. 377.

various illustrations in proof of admirable contrivance in the structure of the globe, with which investigations into its fossil and mineral contents bring us acquainted, the Reverend expositor proceeds: "Thus Geology contributes proofs to Natural Theology strictly in harmony with those derived from other branches of Natural History; and if it be allowed, on the one hand, that these proofs are, in this science, less numerous and obvious, it may be contended, on the other, that they are calculated to lead us a step farther in our inferences. The evidences afforded by the sister sciences exhibit, indeed, the most admirable proofs of design and intelligence originally exerted at the Creation: but many who admit these proofs still doubt the continued superintendance of that intelligence, maintaining that the system of the universe is carried on by the force of the laws originally impressed on matter, without the necessity of fresh interference or continued supervision on the part of the Creator. Such an opinion is indeed founded only on a verbal fallacy; for 'laws impressed on matter' is an expression, which can only denote the continued exertion of the will of the Lawgiver, the Prime Agent, the First Mover: still, however, the opinion has been entertained; and perhaps it nowhere meets with a more direct and palpable refutation, than is afforded by the subserviency of the present structure of the earth to final causes; for that structure is evidently the result of many and violent convulsions subsequent to its original formation. When, therefore, we perceive that the secondary causes producing these convulsions have operated at successive periods, not blindly and at random, but with a direction to beneficial ends, we see at once the proofs of an overruling

Intelligence continuing to superintend, direct, modify, and controul the operation of the agents which He originally ordained.

"Examples of this kind are perhaps nowhere more strikingly afforded than in the instance of those fractures or disturbances called *faults*, which occur in the alternating beds of coal, slaty clay, and sandstone, which are usually associated under the name of coal measures. The occurrence of such faults, and the inclined position in which the strata composing the coal measures are usually laid out, are facts of the highest importance as connected with the accessibility of their mineral contents. From their *inclined position*, the thin strata of coal are worked with greater facility than if they had been horizontal; but as this inclination has a tendency to plunge their lower extremities to a depth that would be inaccessible, a series of faults, or traps, is interposed, by which the component portions of the same formation are arranged in a series of successive tables, or stages, rising one behind the other, and elevated continually upwards towards the surface from their lowest points of depression. A similar effect is often produced by undulations of the strata, which give the united advantage of inclined position, and of keeping them near the surface. The basin-shaped structure, which so frequently occurs in coal fields, has a similar tendency to produce the same beneficial effect.

"But a still more important benefit results from the occurrence of *faults* or *fractures*, without which the contents of no deep coal mine would be accessible. Had the strata of shale and gritstone that alternate with the beds of coal been continuously united without fracture, the quantity of water that would have

penetrated from the surrounding country into any considerable excavations that might have been made in the porous grit beds, would have been insuperable by the powers of the most improved machinery: whereas, by the simple arrangement of a system of faults, the water is admitted only in such quantities as are within controul. Thus the component strata of a coal field are divided into numberless insulated masses or sheets of rock, of irregular form and area, not one of which is continuous in the same plane over any very large district, but each is separated from its next adjacent mass, or sheet, by a dam of clay impenetrable to water, and filling the narrow cavity produced by the fracture which caused the fault.

"If we suppose a thick sheet of ice to be broken into fragments of irregular area, and these fragments again united after receiving a slight degree of irregular inclination to the plane of the original sheet, the united fragments of ice will represent the appearance of the component portions of the broken masses, or sheets, of coal measures we are describing, whilst those intervening portions of more recent ice by which they are held together, represent the clay and rubbish that fill the faults, and form the partition walls that insulate these adjacent portions of strata, which were originally formed like the sheet of ice in one continuous plane. Thus each sheet or inclined table of coal measures is inclosed by a system of more or less vertical walls of broken clay, derivative from its argillaceous shale beds at the moment in which the fracture and dislocation took place: and hence have resulted those joints and separations, which, though they occasionally interrupt at inconvenient positions, and cut off suddenly the progress of the collier, and

often shatter those portions of the strata that are in immediate contact with them, yet are in the main his greatest safeguard, and indeed essential to his operations. The same faults also, whilst they prevent the water from flowing in excessive quantities in situations where it would be detrimental, are at the same time of the greatest service in converting it to purposes of utility, by creating on the surface a series of springs along the line of fault, which often give notice of the fracture that has taken place beneath. It may be added also, that the faults of a coal field, by interrupting the continuity of the respective beds of coal, and causing their truncated edges to abut against those of uninflammable strata of shale or grit, afford a preservative which prevents the ravages of accidental fire from extending beyond the area of that sheet in which it may take its beginning, but which, without the intervention of some such a provision, might lead to the destruction of entire coal fields.

"It is impossible," concludes Dr. Buckland, "to contemplate a disposition of things so well accommodated, and indeed so essential to the various uses which the materials of the earth are calculated to afford to the industry of its inhabitants, and even to the supply of some of their first wants, and entirely to attribute such a system to the blind operation of fortuitous causes. Although it be indeed dangerous hastily to introduce final causes, yet since it is evident that in many branches of physical knowledge, more especially those which relate to all organized matter, the final causes of the subjects with which they are conversant form perhaps that part of them which lies most obviously open to our cognizance, it would surely be as unphilosophical to scruple at the

admission of these causes when the general tenor and evidence of the phenomena naturally suggest them, as it would be to introduce them gratuitously unsupported by such evidence. We may surely, therefore, feel ourselves authorised to view, in the geological arrangement above described, a system of wise and benevolent contrivances prospectively subsidiary to the wants and comforts of the future inhabitants of the globe, and extending itself onwards, from its first formation through all the subsequent revolutions and convulsions that have affected the surface of our planet."

CHAPTER IX.

BORING AND SINKING.

Relative Views of the Miner and the Geologist in searching for Coal—Extent and localities of carboniferous strata mostly ascertained—Superficial indications of Coal—Examination by boring—Description of boring apparatus—Interesting nature of the search after mineral treasures—Sizes of pits—Windlass used in commencement of sinking—Walling inside the shaft—Tubbing—Blasting with gunpowder—Description of the horse gin—Expensiveness of sinking deep pits—Pemberton's shaft at Monkwearmouth—Adits or drifts.

HAVING disposed of the Natural History and geological relations of coal, we now come to treat of its obtainment by means of human industry. However attractive coal might have been or may be considered, as a mere fossil, to scientific enquirers into the nature and formation of the earth, it is mainly to considerations connected with its importance as the most valuable species of fuel, that we owe our so large and generally accurate acquaintance with its properties and situation. For, let the zeal of the geologist be what it may in pushing scientific inves-

tigations over various countries to a great extent, or to whatever depths in the earth on a given spot, the practical self-interest of the collier will rarely fail to surpass it in exploring any locality where coal is likely to be found. These parties, indeed, are not commonly found proceeding in concert, at least, the latter has only been induced of late years to defer to the former in reference to strictly untried ground; and perhaps the advantages which would arise from the working of thick seams of good coal, sufficiently account for the many unsuccessful attempts to discover them. "The opinions of working colliers on this point," observes Mr. Phillips,* "have too often been preferred to the legitimate deductions of science; and even yet persons will perhaps be found willing to credit the delusive tale of finding good coal by *going deeper*."

Formerly, the absurd and arbitrary notion that coal might be found any where in this Island by only sinking deep enough, prevailed to a considerable extent. Men of the present generation residing in or about London, may have heard their grandmothers gravely assert that coal might be raised from under Blackheath, and other equally unlikely places, were it not that Government did not allow the search lest the discovery might interfere with that "nursery for seamen," the coast coal trade! It is allowed by experienced geologists, that workable coal may hereafter be discovered in some new situations or at great depths; as, for instance, covered by magnesian limestone or red sandstone, or beneath the lias, as the coal measures of Durham and Western Yorkshire, appear in some instances to run under these sub-

* Geology of Yorkshire, p. 182.

bones in animals: if the flesh is removed, the whole structure of the bones, their situation and connection, are at once discovered; in the same manner, were the alluvial covering removed, the whole strata would be distinctly seen, and the effect of every dislocation immediately ascertained. But, however the total removal of the alluvial cover might, in one view, appear to be of great advantage, as affording facility in ascertaining the mineral contents of any district, yet this convenience would be greatly outweighed by the disadvantages, not only in the loss of soil at present available for purposes of cultivation, but likewise in consequence of the strata being denuded, the coal-mines would be deluged during every rainy season; whereas the alluvial cover affords protection, by causing the water to flow along the surface till it joins the rivers, which are the great natural drains for the moisture on the surface of the earth.

The usual, and most certain, method of ascertaining the mineral contents of any given spot, whatever be the superficial indications, or proximate circumstances of it, is by Boring. This process determines at once and satisfactorily, and at comparatively little cost, the order of the different substances, from the surface to any given depth; also the exact thickness of each stratum at the place of section, and consequently affords the best data not only as to the actual existence of coal, but with reference to how far it may be of a kind, or lie in seams sufficiently thick, or at such depth, as may justify the sinking of a shaft, the erection of enginery, and the general working of the bed or beds. The following sketch is a representation of the apparatus for boring, as commonly constructed.

Fig. 20.

A spot being fixed upon, the first object of the workmen is to obtain a stout springing pole A, which is twelve or fourteen yards in length, and generally, where practicable, made of a tree fresh felled and bough-lopped for the purpose. It is securely fastened down at the thick end, a short distance from which it rests upon the prop or bearer B. Near the small end, a wooden stave is passed through, affording convenient hand-hold for two men, when standing on the stage C. Over this stage, and also exactly over the spot where the boring is to take place, a triangle D, is erected, consisting of three poles fastened at the apex, and sustaining a pully-block and rope—the latter attached to the windlass E. The use of this tackle will presently appear. A flooring of planks, F G, is then laid down, having a hole in the centre through which the rods are to work. These rods H K, are of iron, four feet long, an inch in diameter, and tapped with good screws at their ends, which are made somewhat swelling out to give strength. The lowermost rod, or that which in boring actually operates upon the rock or other stratum, is a sort of chisel, K; the uppermost terminates in a stout ring, through which passes the cross-piece L, and which, in working, is taken hold of by two men: it is also

suspended to the springing-pole by a chain. One of the rods is formed at the end with a shell like a common auger, and is used for the purpose of bringing up at intervals portions of the detritus produced by the action of the chisel. The mode of operation is as follows:—one, or more rods being pushed into the ground, through the hole in the planks, the two men on the stage, taking hold of the cross-stave at the end of the springing-pole, work it steadily up and down; while the two men below, by means of the cross-piece, simultaneously heave and depress the suspended rods, walking at the same time slowly round the hole—by these combined operations of chopping and scooping, making way through whatever substance may be in contact with the steel chisel of the lowest rod. When the boring becomes somewhat obstructed by the accumulation of *wreck*, as the workmen call the mine stuff produced by the working of the chisel, or when they wish to ascertain what stratum they are passing through, the rods are drawn out by means of the tackle above described, the chisel is unscrewed off, and replaced by the shell, which is then lowered to extract the loose matter for clearage and examination. M is the spanner used in screwing and unscrewing the rods; and N an iron fork, the prongs of which are placed across the rods below the swell, and in contact with the floor, to prevent the lower series from slipping down, while the upper one is being screwed off or on.

The chisel soonest becomes clogged, and the tiresome operation of withdrawing the rods, is required to be repeated most frequently, when the stratum is somewhat soft and dry; on the other hand, the boring goes on most pleasantly for the workmen, when a

strong spring of water is tapped, as this generally overflowing, brings up with it to the orifice, every particle of the wreck as it is produced. The diameter of these borings is commonly from 2½ to 5 inches—rarely so much as the latter.

By this method, the stratification below any given plot of ground, is examined at a trifling expense, and with considerable precision. Williams, in his quaint style, has pourtrayed the pleasure attending these investigations—when successful:—"Of all branches of business," says he, "of all the experiments that a man of sensibility can be employed in, or attend to, there is perhaps none so amusing, so engaging, and delightful, as a successful trial upon the vestigia or appearances of a seam of coal or other mineral discoveries. When you are attending the people who are digging down or forward upon the vestige of the coal, and the indications are increasing and still growing better under your eye, the spirit of curiosity and attention is awakened, and all the powers of expectation are elevated in pleasing hopes of success; and when your wishes are at length actually crowned with success, when you have discovered a good coal of sufficient thickness, and that all circumstances are favourable, the heart then triumphs in the accomplishment of its wishes with solid and satisfactory joy. There is more rational delight, more substantial pleasure and happiness, to be enjoyed in such scenes as this, than in all the celebrated amusements which luxury invents and pursues." He should have added that the mortifications attendant on disappointment are often proportionably trying.

Having ascertained the existence, and workable

condition of coal, by means of boring or otherwise, the next business is the sinking of the shaft. This work, as well as the preceding, is not undertaken by the regular colliers, but by a separate class of men called sinkers. In the northern collieries the pits are invariably circular, and varying in their diameters from six to twelve feet. It is common to divide the very deep shafts by a brattice or boarded partition from top to bottom, the use of which will afterwards appear—in these cases, the diameter is usually from 8 to 10 feet: sometimes the shaft is divided into three parts, and then it is generally from 10 to 12 feet across; from 6 to 8 feet is a regular size where no brattice is intended. In Yorkshire, Staffordshire, and other places, where the distances between the surface to the coal are inconsiderable as compared with those about Newcastle, it is common to sink, of the smaller size, separate shafts for pumping, ventilating, and drawing the coals: occasionally, too, the pits for the latter purpose are oval in their form.

The situation, form, and size of the pit being determined, operations are commenced by digging out the soil to a proper extent, and then erecting a windlass, called in some places *stowses*, or *turn-stakes*. This very ancient mining apparatus is generally known: it consists of two upright cheeks resting on cross pieces, and cut at the upper end of each, for the reception of the iron axes of a roller, having a stout winch handle, exactly similar to that seen over most draw-wells: upon this roller the rope is wound. At the end of the rope is the large iron hook made with a catch, to prevent it from slipping off the bow of the corve or tub used in drawing up the materials. The tubs, which were formerly used, have now

mostly given way to large wrought iron buckets placed upon soles shod with iron in the manner of a sledge, that they may be dragged along with the greater ease by means of a hooked rod and cross-piece, or handle. The ordinary tools of the sinker are, mattocks, gavelock, a sledge hammer twenty pounds weight, and several short stout wedges; also a smaller hammer, long chisels, and an iron skewer for setting shots.

After the sinking has proceeded some yards, more or less according to the nature of the strata excavated, it is necessary to commence operations for securing the whole interior of the shaft—except in very solid parts—by means of a lining of brick. This cylindrical wall, or *ginging*, is raised upon a circular frame-work of wood called a crib, and which is itself made to rest, where practicable, upon a rocky or other solid ledge; or, where the matter passed through is loose, those timbers which support the brick-work are themselves upheld by keys driven into the sides of the pit, or even suspended by chains from the top. The sinking is then resumed, and, in due course, another circuit of cribbing is laid, and a section of walling carried up, till it joins the lower part of the preceding fabric. These operations and precautions are repeated at intervals, more or less frequently according to the nature of the strata; the rocky portions do not always require such support. In order to secure that the shaft be regular in circumference, and accurate in perpendicular descent, a plumb-line is occasionally suspended from the top to the bottom, and the distance of the sides from the centre—generally about five feet—measured by means of a stick kept for the purpose. All this is easily done when

the pit is circular, which is most common, or square, which rarely occurs; but when oval, as is sometimes the case, the measurement, having to be made from three centres, is more difficult; and accordingly the sinkers pride themselves, when they can work with perfect accuracy under the latter circumstances.

When the substances passed through prove dry, the work proceeds without difficulty; but when water occurs, as is generally the case, and spouting, as it sometimes does, from several points of the circumference of the excavation, it is no easy matter to manage either the above-mentioned erection, or the sinking, satisfactorily. Means, however, are taken, generally by oblique gutters cut behind the wall, or by the fixing of boards to conduct the streams to the floor, when it is either laded out into the bucket with the stuff dug up, or, if very abundant, sent out in an eighteen-gallon tub, lowered alternately with the bucket. In some instances, the interior of the shaft, when the water cannot be stopped or diverted sufficiently by the brick lining, is farther cased with boards nailed from one crib to another. These surrounding spouts in the Staffordshire pits are called *garland circles:* in some shafts there are not fewer than six or eight of these garland circles, by means of which the side water is collected and carried by an inclined drift or bore to the engine-pit.

In the pits about Newcastle, and elsewhere, when great durability and firmness are aimed at, as well as an effectual means of keeping out the water, required at whatever expense, this casing of the interior with wood is very substantially effected. It is called tubbing. The earliest application of the system of lining shafts with wood, from which the appel-

lation of tubbing seems to have been derived, was the spiking of 2½ or 3-inch planks (properly dressed to the sweep of the pit) to cribs or supports of 6 or 8 inches square, placed at intervals of 2 or 3 feet. With this description of tubbing was effected the winning of Hebburn, Jarrow, South Shields, and other collieries in the neighbourhood of Newcastle, about and since the year 1790; in which collieries some of these tubs are sustaining water under a pressure of 40 fathoms, or 100 lbs. per square inch.

About the year 1795, the late Mr. Barnes at the King Pit, Walker Colliery, on the Tyne, introduced cast-iron tubbing, consisting of entire circular rims the size of the shaft; these were found exceedingly convenient in passing through sand and other loose matter, especially near the surface. The improvement, however, which has given to this kind of security its full convenience and efficiency, was the plan of casting the metal cylinder in segments adopted by Mr. Buddle, in the winning of Percy Main Colliery in 1796. In the cast iron work of this intelligent individual, to whose scientific and professional exertions the mining district about Newcastle is indebted for so many of its greatest improvements,* the flanches were bolted together and projected inside towards the centre of the pit. This inconvenience was removed, and cast iron tubbing carried apparently to its limit of useful application, when a plan was adopted for putting the segments together without screw bolts at

* It may not be uninteresting here to mention that Mr. Buddle has presented to the Natural History Society of Newcastle-upon-Tyne, the various plans, sections, and written documents accumulated by him through a long period of professional experience, as one of the most intelligent and respectable coal viewers in that district: he has also suggested to the Society the propriety of making a collection of mining records, according to a plan which he laid down.

all, in the winning of Howden Pit in 1805, since which time this method has been universally adopted. Mr. Buddle mentions one instance in his experience, where, in sinking a shaft he had occasion to insert forty fathoms of iron tubbing; at that depth the strata became impervious to water.

In order to break up such rocky masses, as cannot be separated by the gavelock, recourse is had to blasting, a somewhat dangerous but highly effective agency. In "setting a shot," as the miners term it, the first operation is the making of a hole in the solid substance of the stone; this is done by a succession of strokes upon the head of a long stout chisel held in the hand of the workmen, and turned about, as in the method of boring before described. The hole is of a triangular shape, about two inches in diameter, and thirty inches deep—more or less, according to the thickness of the substance in which it is made. The direction of the bore, and position of the angles in relation to the matter to be detached, are of importance, and can be so adapted by experienced sinkers as to enable them to form in general, a very accurate estimate of the effect of the explosion. If the hole be too shallow, the shot will merely rive away a superficial portion of the rock; if, on the other hand, it be sunk nearly through the mass, it will burst downward, and spend itself among the interstices of the stratum. After the hole is bored, it is charged with gunpowder, to the depth of several inches: a long "pricker" or skewer is then put down in one of the angles, and filled about with marl, or such stuff as may be at hand; this is rammed with an iron rod, care being taken not to strike a spark from the adjacent materials—from which occurrence

dreadful accidents have sometimes happened. When this part of the operation is finished, the pricker is withdrawn, and a wheaten straw filled with powder, and to the top of which a slip of touch-paper, or paper merely greased, is stuck with a bit of clay, is inserted: a light is then applied, and the miner is drawn up as quickly as possible. It is the practice, sometimes, instead of inserting the fuze, to cover the hole with gunpowder, scattering at the same time a considerable quantity over the pit bottom, upon which fire is thrown from above: this slovenly and wasteful plan was exclusively in use half a century ago.

When the sinking has proceeded to such a depth that the labour of drawing up the matter by means of the windlass becomes exceedingly great, a machine called a gin is generally set up, the stones and rubbish already brought up being used in the formation of what is called the gin-race, or circular track in which the horse attached to the machine travels. The following is a representation of the gin, which

Fig. 21.

was the most perfect contrivance for drawing coals and water out of the mine previously to the introduction of the steam-engine: it is still extensively

used in many small concerns, where the produce does not justify the erection of a more expensive apparatus.

A, the head-gear, consisting of two upright posts in which wheels are fixed, and over which those portions of the rope to which the buckets are attached pass into the pit. B, a drum, or short wooden cylinder, about five or six yards in diameter, upon which the rope winds: this drum has a vertical shaft, to a cross-piece of which at C, the horse is attached; its lower end rests in a socket on the ground, and is supported above by the transverse beam D, raised on standards at each end. The rope being wound about the gin, the horse is driven in one direction until one bucket is lowered to the bottom and the other raised to the surface—and then, by reversing his course, the latter bucket, having been emptied at the bank, is made to descend, and the other as filled below is drawn up.

The expense attendant upon sinking a shaft will depend, of course, a good deal upon the depth and nature of the strata requiring to be penetrated. Mr. Buddle states that in Northumberland, he has, in several cases, known a single pit, previously to its being worked, cost upwards of £70,000. This sum included the machinery requisite for sinking the pit, namely, the steam-engine and all its apparatus; but as this was merely to get at the coal, it may be considered as a winning charge, rather than a working charge. The deepest pit with which the gentleman above named was acquainted, as a working pit, was 180 fathoms of shaft; the shallowest 23 fathoms; but the pitmen sometimes descend much deeper by means of inclined planes under ground.

The shaft at present sinking at Monkwearmouth Colliery, near Sunderland, has attained a considerably greater depth than any mine in Great Britain, (or estimating its depth from the level of the sea, than any mine in the world.) It was commenced in May, 1826. The upper part of the pit is sunk through the lower magnesian limestone strata, which overlap the south-eastern district of the Great Newcastle Coal-field, and which, including a stratum of "freestone sand" at the bottom of the limestone, extended at Monkwearmouth, to the thickness of 330 feet, and discharged towards the bottom of the strata the prodigious quantity of 3000 gallons of water per minute,—for the raising of which into an off-take drift, a double-acting steam-engine, working with a power of from 180 to 200 horses, was found necessary. The first unequivocal stratum of the coal formation, viz., a bed of coal 1½ inches thick, was not reached till August, 1831, (being about 344 feet below the surface,) after which the tremendous influx of water which had so long impeded the sinking operations was "stopped back" by the metal tubbing which extended from the above bed of coal to within 26 yards of the surface. The sinking now proceeded with spirit—still, no valuable bed of coal was reached, although the shaft had passed considerably above 600 feet into the coal measures, and much deeper than had hitherto been found requisite for reaching some of the known seams. It became evident that the miners were in unknown ground. A new "feeder" of water was encountered at the great depth of 1000 feet, requiring fresh pumps and a fresh outlay of money. The prospects of the owners became unpromising in the eyes of most men, and were denounced as hope-

less by many of the coal-viewers!* Coal-viewing, however, had as yet been limited to some 200 or 220 fathoms; and the views of the Messrs. Pemberton (the enterprising owners of this colliery) were not to be bounded by such ordinary depths; they considered that the thickness of the coal formation might be vastly greater where protected by the super-incumbent limestone, than where exposed to those denudations which, in the neighbourhood of the "rise" collieries, had probably swept away the strata through which their own shaft had hitherto been sunk; that they were, therefore, justified in anticipating the larger and known seams at greater depths; and that, in case these larger seams had (as was intimated) been split into smaller strata, the same causes which in other places had produced their subdivision might, at Monkwearmouth, have effected their junction. They continued, therefore, their sinking, and in October, 1834, reached a seam of considerable value and thickness, at the depth of 1578 feet below the surface; and presuming that this newly discovered seam was identified with the Bensham seam of the Tyne, (or Maudlin seam of the Wear,) they are rapidly deepening their shaft, in anticipation of reaching the Hutton or most valuable seam, at no distant period, but which (if their anticipations are well founded) will be found at a depth approaching 300 fathoms from the surface!! In the mean time, however, workings have been commenced in the supposed Bensham seam, though not as yet carried to any great extent: and when only a few days before this sheet went to press (April 1835) the writer paid a visit to the pit, he found the sinking still going on,

* Durham Advertiser.

the depth reached being about 265 fathoms. The outlay of capital in this spirited undertaking has been immense—it is said not less than between £80,000 and £100,000.

As pertaining immediately to the province of the sinker may be mentioned the driving of thirls, or adits, for the emission of water at what are called *day-levels.* This was a primitive method of draining coal in situations which rendered the adoption of such an expedient available; and especially before the introduction of hydraulic machinery, or the steam engine. The particular mention of *drifts* to carry off the water, occurs, in connexion with the sinking of pits at Ferryhill, in a lease to the Prior of Durham dated in 1354. The old Preston Grange Colliery near Edinburgh, abandoned in 1746 on account of being inundated, discharged 220 gallons per minute, by means of a drift, into the Frith of Forth. In South Wales the numerous deep valleys intersecting the coal country, afford many favourable opportunities for this kind of drainage: in general these adits are used as canals for bringing out the coals. Since the application of steam power in its most efficient forms, some gigantic undertakings for carrying off the water by day levels have been completed: the Cornish adit, for example, which drains about fifty mines, extending its ramifications about 26,000 fathoms, or nearly thirty miles, is a prodigious work of this kind: it empties itself into the sea at Falmouth harbour. The adit of the Duke of Bridgewater's collieries at Worsley is about thirty miles long, and navigable for barges used in the extraction and transit of the coals. There are several others of great extent, and that have been the subject of enormous expense in different parts of the country, particularly in the lead mining districts.

Few operations can be conceived more unpleasant and dangerous to the workmen, than the execution of these adits, especially when, as is sometimes the case, they are barely wide enough to allow the sinker to creep along. The dangers which are created by blasting the solid rock with gunpowder in such confined spaces, will be easily conceived: in the stillness of night the report of these explosions is sometimes heard to a distance of three or four miles; and the writer of this recollects on one occasion to have heard the wife of an intrepid sinker describe the feelings with which, at midnight, she used to hear when in bed, the reverberation of every shot fired by her husband in his dangerous subterranean toil, at a distance of two miles at least.

CHAPTER X.

WORKING MACHINERY.

Drawing and air shafts—Importance of Ventilation—Draining the Mine—Bearing of strata—Early contrivances for raising the water—Bucket wheels—Steam-engine—Boulton and Watt—Pumping apparatus—Subterranean Steam-engines—Deep Pits divided by Bratticing—Head Gear—Whimsey—Steam-engine and counterpoise—Hydraulic Machinery for raising Coals—Corves, Trams, Buckets, and Waggons—Screen—Entrance to Pits by Canals and Footrails.

ASSUMING, in accordance with the preceding Chapter, that a shaft is sunk to the coal, and properly secured against the irruption of loose shattery sand or gravel, as well as of water, by wood or iron tubbing, it is proper farther to state, that this shaft must either be divided down the middle by a partition of boards, so as to form upcast and downcast tubes for ventilation, and, in some cases, to serve for engine-pumps, as well as drawing coals; or else, that another pit must be sunk, to be connected with the former by means of an underground drift, and thus afford a circulation of air. In very deep pits, the saving of expense

commonly compels the former course; in other cases, the latter method is adopted. In Staffordshire, it is usual to sink "a pair of pits"; the establishment of works for a single colliery being called "a plant," or plantation.

That most important particular in the economy of our mines, and upon which the health and lives of the colliers so much depend—namely, Ventilation—has been the theme of a great deal of discussion—not always temperately conducted. The philanthropist has sometimes upbraided the coal-viewer with murder, for neglecting the trial of some theory of injecting or circulating air; while the viewer, in turn, has occasionally scouted, with perhaps too little ceremony, schemes which appeared ingenious and plausible enough on paper, but which might be to him obviously unavailable in practice. It will at once be apparent, that the mere existence of two or more pits at any given distance from each other, would do little, if any thing, toward cooling the interior of the mine, and changing the respirable air: the pits would simply stand, full of air, as in two vessels, under similar circumstances, water would stand at one level. Air must, therefore, be either artificially forced down one of the vents, or it must be made to descend by altering the quality of the subincumbent portion: both these methods have been resorted to—the latter with most success. As the natural tendency of the atmosphere to restore its equilibrium, causes the general volume to travel by the nearest direct channel toward any place where a partial vacuum is formed; and as the object of the miner is to counteract, or rather to take advantage of, this law, stoppages are so arranged in the workings, by

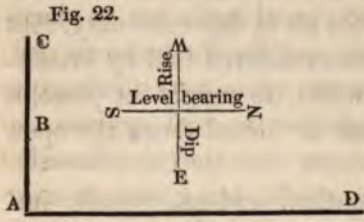
trap-doors * or other means, that the current brought down the working pit, instead of being allowed to rush to the air-pit directly, is first made to circulate as deviously and extensively as possible. We shall have occasion to advert to this arrangement again, and more particularly. The draught is created, or a sort of vacuum formed in the air-pit, sometimes simply by the suspension of a pan of burning coals, but more perfectly by closing the pit overhead, with the exception of a chimney, and keeping up a fire therein, either near the top or at the bottom, as most convenient: thus by rarifying the air at this extremity, that portion of it which has been rendered foul by breathing rushes to the heat, while, to supply its place, a new and unvitiated volume is forced down the open pit.

The next object of attention, and one equally important with ventilation, is the Draining of the Works. In almost every colliery there is more or less water—in most so much, that the pumping of it out of the workings is an affair of considerable importance; and sometimes it is necessary to erect the steam-engine, and work it for this purpose, during the sinking—the pumps being suspended and lengthened as the shaft increases in depth. It must at once occur to the reader, that, as the strata of every coal field have a certain inclination with respect to the horizon, called the *dip* and *rise*, as well as commonly a level line of bearing, forming right angles therewith (to say nothing of

* The boys who attend to open and shut these doors, are called trappers: they have seats near the doors, and remain by them all the time the pit is at work. As these trap-doors are, as it were, the air-valves, by means of which the ventilation of the works, in connection with underground passages, is kept up, a proper attention to them is a matter of great importance. They are, however, on account of the simplicity of the duty to be performed, commonly entrusted to young boys on their first entrance upon work.

the many other complex modifications occurring in practice); and, as the drainage will generally follow the descent of the measures, it will be necessary to select such a situation for the engine-pit, that, as the excavations in getting the coal are extended, the water, instead of accumulating in the works, may run off to the place of the pumps. With this design it is usual to sink the engine-pit at the lower part of the field, the drawing shaft being at a short distance above on the rise of the strata. The annexed diagram will sufficiently explain the arrangement.

Fig. 22.



Suppose the cross lines to indicate a tract containing coal measures, which rise to the west and dip towards the east, the cross bearing of the strata having a slight inclination from north to south. The course of winning would be—having sunk the engine-pit at A, nearest the lowest angle of the ground, and the working-pit at B, a little higher up, and having opened a passage between them, the next operation would be, to cut a drift or water-course along the lowermost level of the tract from A to D, so that when what is called the winning headway, or main thoroughfare, is excavated from A to C, and the engine and drawing apparatus got to work, the coal is said to be won. The water from the workings which are carried on the rise, mostly flowing off by means of cross galleries to the sump, or well in which the pumps work; some portion also, it may be, running down the headway A C.

Prior to Mr. Newcomen's application of steam

to raising water from coal mines, both the water and coal were usually raised by means of engines wrought by horses, a method still in use among some land-sale collieries. About two centuries ago, a patent was granted by James VI. of Scotland, for the discovery of an engine for raising water from coal mines.* In 1630, a charter was also given to a person called David Ramsay for a similar invention.† Sometime after "Master Beaumont, a gentleman from the south, brought with him rare engines to draw water out of the pits,"‡ at Newcastle. At the Lumley collieries, about 1676, "the engines were placed in the lowest places, that there may be the less way for the water to rise; and if there be a running stream to work the engines it is happy. Chain pumps are the best engines, for they draw constant and even: but they can have but two stories of them; the second being with an axle-tree of seven or eight fathoms, and the deepest story is wrought by buckets, and a wheel and ropes with the force at the top."§ These contrivances were, on the whole, clumsy, dangerous, expensive, and inefficient. Mr. Bald, in his view of the coal trade of Scotland, printed in 1812, informs us that about 1690, water wheels and chains of buckets were commonly employed to drain collieries in that country. The axle of the wheel extended across the pit mouth, and small wheels were fixed upon the axle to receive endless chains of two or three tiers—which reached down to the coal. To these chains were attached a number of oblong wooden buckets or troughs in a horizontal position, which circulated continually with the chains ascending on one side and descending on

* Arn. Hist. of Edinb. 66.
† Rymer Fœd. l. xix. f. 189.
‡ Grey's Chorographia, 26.
§ North's Life of Guildford, p. 137.

the other, filling at the bottom, coming up full, and discharging at the top, as they turned over the wheels on the great axletree, and then descending empty to be filled again. Such a contrivance was very imperfect: not only was there required a considerable head of water to turn the large wheel; but of that which was taken up by the buckets no small portion of it was spilled before it reached the top: besides, the machine was very expensive, costing, for a pit of eighty yards, not less than £160: there were likewise constant repairs—for, when a joint-pin gave way, the whole set of chains and buckets fell to the bottom with a most tremendous crash, and every bucket was splintered to pieces.

Where water could not be procured to work these machines, the same sort of machinery, only on a smaller scale, was adopted to be moved by horses. These were comparatively very expensive, and could only draw water from a small depth; so that those deeper fields of coal, where neither a day level nor water machinery could be employed, remained useless—and that to all appearance, for ever, as there was no other device for getting clear of the water.

From the same authority we learn, that in the year 1708, wind mills were erected to work pumps in several collieries in Scotland; but these, although efficient machines at times, were very irregular; and in calm weather the mines were drowned and the workmen thrown idle.

In the year 1709, John Earl of Mar, who paid the most minute attention to the improvement of his collieries in Clackmannanshire, sent the manager of his works to Newcastle to inspect the machinery of that district, and learn the mode of conducting colliery

operations in every department. From his report it appears, that the machines then in use were water wheels and horse engines, with chain pumps; the common depth of the pits was from twenty to thirty fathoms, and a few from fifty to sixty fathoms; the expense of sinking one of these was about £55; and the machine for drawing the coals cost only £28. It appears that when it was requisite to draw water from the depth of thirty fathoms, two pits were sunk at a little distance from each other; one pit was made thirty fathoms deep, the other only half that depth. One machine drew the water half way up the deep pit, and then it was poured into a mine, which communicated with the bottom of the other pit: from this the water was raised to the surface by another machine. In deeper mines, a third pit, with a third machine, was resorted to. But in Scotland, at the same time, the machinery was more powerful; as water was raised at once from the depth of forty fathoms, by the chain of buckets before described.*

Though it is generally admitted that the Marquis of Worcester has referred to some kind of a steam-engine, in his "Century of Inventions," so early as 1655, there was no practical application of any such machinery, so far as is known, until more than half a century afterwards. One of the earliest recorded experiments having been made at the colliery of Griff, near Coventry, where the proprietors are said to have maintained a great number of horses, at a vast expense. Mr. Hodgson states, that the first seen in the county of Northumberland,† was erected at Byker,

* Bald, as quoted in Farey's Treatise on the Steam Engine, p. 227.

† To an individual in that county is attributed a contrivance, the origin of which has often been alluded to in various ways—in 1718, Mr. Beighton, of Newcastle-upon-Tyne, removed the flimsy strings and catches with which

in 1714, by the son of a Swedish Nobleman, who taught mathematics in Newcastle. "This powerful engine is now in common use in all the large collieries. As simplifiers of it, the names of Messrs. Boulton and Watt, as well as that of the ingenious builder of the Eddystone light-house, will be long remembered." When the last-named party, under the sanction of their patent, introduced the improved steam engines into the mining districts, they stipulated, after receiving a large price for the engines put down, to divide with the parties working them, the amounts accruing from the saving of fuel effected, as compared with the old machines; and so profitable was this arrangement, especially in Cornwall, where coal was dear, that one concern (the Consolidated Mines Company), using three powerful engines, paid to the patentees £2,400 per annum.

The pumps, of which there may be one or more in each pit according to circumstances, are of a size proportionate to the work to be done: sometimes they are 12, 18, and even as much as 24 inches in diameter. If there be two or three pumps or cylinders, as is sometimes the case, they are placed side by side, and supported at intervals by beams fixed across the pit; cisterns being placed at different elevations to which the water is raised, and if possible delivered off by an adit considerably below the surface: in some instances also, cisterns are placed at the level of feeders of water that occur at a distance of many fathoms from the bottom, and deliver some hundreds of gallons per minute, so as to save the waste of steam power which would be consequent on allowing this

the self-acting engine had, till that time, been incumbered, and applied lever-rods for opening and shutting the cocks, which seemed to perfect the machine.

water to fall to the sump, in order to raise it through the whole length of the pumps. The hydraulic action is exactly similar to that of a common sucking pump. The bucket in each cylinder consists of a stout rim of iron, surrounded with thick leather, and having a cross bar, to which are hinged two valves or clacks opening upwards: there is also a similar contrivance made stationary near the bottom of the pump. The rods or spears to which the working buckets are attached, are fastened with cottars on each side of a piece of wood, which is suspended by chains on the head of the engine beam, which projects through an opening in the engine-house, and over the pit: it has a lug or bracket on each side, and which fall upon pieces of timber, and thus prevent the rods from sinking too low. To the upper part of its face the rods, as already stated, are suspended by a stout chain, exactly resembling in construction that inside a watch: occasionally, the more scientific contrivance for affecting the parallel motion, by means of iron rods, is adopted. In order to avoid the inconvenience resulting from the immense weight of the pump rods in very deep mines, as well as to serve other purposes, there have been instances of the erection of steam-engines 100 fathoms below the surface. Mr. Farey mentions an instance of an engine working underground in a colliery at Whitehaven in 1776. It was placed 80 fathoms beneath the surface, and worked a series of pumps disposed down the dip or inclination of the strata of coal, which was very rapid. The pumps lifted four fathoms each, from one to another, and were worked by one sliding rod from the engine. The intention of this disposition was to avoid piercing the floor, which

must have been done with a perpendicular pit, and thus have let much water upon the workings. The same authority adds :—" In many situations where the bed of coal dips suddenly, and if the strata beneath the coals be of a porous nature, it is of great importance to preserve the water-tight floor of the coal perfect, in order to prevent the passage of the water ; and in all such cases the pumps must be placed on the slope of the strata, instead of in perpendicular pits."* In the Alfred pit at Jarrow, there is a 30-horse steam-engine erected at a depth of about 130 fathoms below the surface : it is used in raising the coals up a shaft which unites with the workings, carried out 45 fathoms deeper still : there is likewise at the profound depth indicated by these two shafts, another steam-engine, to draw the coals up an inclined plane that lies coincident with the dip of the strata.

We may now proceed to describe the arrangements adopted for raising the coal. The erection of head-gear will depend much, not only upon the description of machinery to be employed, but also upon the number and shape of the corves intended to be used. In some of the Staffordshire collieries, two pits are sometimes sunk sufficiently near each other to be worked by the same gin or whimsey, one of the buckets or corves ascending, while the other is descending in a separate shaft. In certain situations of this sort, the erection over the pit-mouth is exceedingly simple and inexpensive, consisting sometimes of nothing more than an inclined piece of timber with a pulley at the end for the rope to pass over, and supported by wooden props, as represented in

* Treatise on Steam-Engine, p. 238.

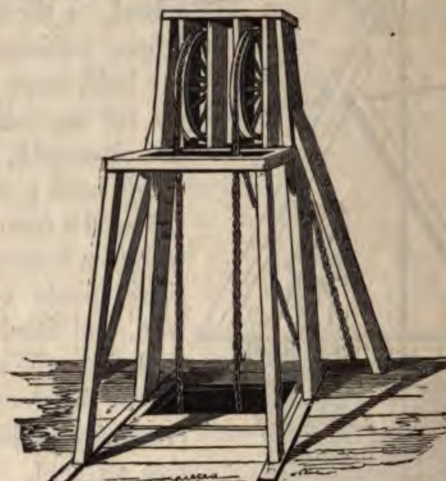
the accompanying sketch (*fig.* 23). A is the profile of the parallel beams which support the head wheel. B the banksman, whose business it is to lay hold upon the corve on its ascending above the pit-mouth, by means of his hook; and having released it from the chain, to hurry it away. C the corfe, made of ribs of iron, and filled with hard coal. E E the rope which passes between the second pit and the whimsey (*see fig.* 24).

Fig. 23.

The more common structure, however, is similar in general arrangement to the delineation on next page (*fig.* 24). Two cast-iron wheels, 4 feet diameter, either with grooved edges for round ropes, or with cylindrical surfaces for flat ropes, are elevated beside one another in the upper part of a framework of timber over the mouth of the pit: the whole is rendered very substantial by buttresses applied on every side. In some collieries chains are used; they are reckoned more economical than ropes, but the links are more liable to snap without giving warning by appearances of wearing or otherwise, than is generally the case with ropes. A flat rope, con-

sisting of four round ones sewed together, and invented by the late John Curr, Esq. of Belle Vue,

Fig. 24.



near Sheffield, is in general use. The ropes or chains pass from the head wheels to the drum of the gin, or to a wooden cylinder, on the axle of a wheel worked by an adjacent steam-engine, upon which they are wound. The annexed cut represents the exterior appearance of one of the old-fashioned steam-engines, still very common about collieries, and called a whim,

Fig. 25.

or whimsey (*fig.* 25). A the engine-beam. B the boiler. C the working cylinder. D the fly-wheel. F the cog-wheel, carrying the drum upon which the rope is wound. E E the ropes, passing to the head-gear (*see fig.* 23). In the working of this machinery, the engine-tenter stands with his hand upon a lever, to stop the steam, and stay the action of the whole, the moment he sees the corfe aboveground.

In some collieries, the engines of Boulton and Watt, or others of an expensive description, are erected, as well for drawing out the coals, as for pumping up the water. In drawing the loaded corves up the deep shafts on the Tyne and Wear, it is commonly found necessary to aid the power of the steam-engine in the earlier stage of its operation, by means of an ingenious contrivance called *a counter-weight.* The plan is this: a few yards from the drawing machinery, a pit is sunk for the reception of a ponderous chain, which, passing over a pulley elevated on posts, is attached to the shaft of the drum upon which the main rope winds. When the power of the engine begins to be exerted in raising the corves from the bottom of the pit, this chain, many of the terminal links of which weigh 100 lbs., likewise exerts a degree of aid proportionate to its weight. As, however, the engine acquires energy by the elevation of the loaded, and the descent of the empty corves, the ponderous links of the chain fall upon each other at the bottom of the counterpoise pit, until the engine, having raised its load to a position which leaves surplus power, the chain, being reversed on its drum, begins to be wound up; thus countervailing the velocity of the machinery at its maximum, as it had previously aided it at its stage of least efficiency.

The annexed slight profile sketch of the works at Carville on the Tyne, in the Wallsend group of collieries, will give some idea of the arrangements above

Fig. 26.

described (*fig.* 26). A the tall brick funnel adjacent to the upcast shaft. B the smoke disperser. C a platform for convenience of cleansing, repairs, &c. D head-gear (*fig.* 24.) over the drawing pit, supporting the wheels over which the ropes pass. E engine-house, containing the fly-wheel, winding cylinders, and other machinery. F counterpoise.

It should be mentioned that previously to the application of steam, by what was at first termed the "fire engine," a great variety of expedients for drawing coals were devised. "The most ancient machine in my knowledge, now [1797] in use," says Mr. Curr, "is that invented by Menzey; but there are few situations that afford the requisites necessary to that invention. A stream of water, with a fall of about half the depth of the pit is necessary, if any business of consequence must be done. Its construction consists of two rope wheels fixed upon one horizontal axis, which are so proportioned to the

depths of the water pit and coal pit, as to reach the separate depths of the pits, by the same revolutions; and the power applied is a tub of water large enough to overbalance the weight to be drawn. The second is the common machine, greatly in use in the neighbourhood of Newcastle-upon-Tyne, the construction of which is, a water wheel and a rope wheel upon one horizontal axis; and the power is a stream of water, sufficient to overbalance the weight to be drawn. The method of obtaining this stream of water in the neighbourhood of Newcastle and Sunderland, where there are, I presume, no less than 30 or 40 in number, is a fire-engine placed by the side of the machine, which raises the water alternately to the top of the wheel; but in two collieries where I have adopted them, the scheme is more advantageous than those at Newcastle, being able to do without a fire-engine erected solely for that purpose; in the winter season when water is plentiful, and the engines are generally sufficiently employed with draining the collieries, we have the aid of adjoining brooks, which do our business; and in the summer season, our engines are so constructed, as to apply a part of their power to raise the water to the top of the wheel."* So rapid have been the steps by which the steam engine has been advanced from the primitive model, to its present degree of perfection, that one finds some difficulty in conceiving of its employment, no longer than from thirty to forty years since, being merely that of pumping water upon a wheel in the absence of natural brooks!

We noticed, not long since, a contrivance for raising coals on a principle similar to the foregoing,

* Coal Viewer and Engine Builder's Practical Companion, p. 34.

at a coal-work in Derbyshire. The vicinity of a pit newly sunk for working, happening to include an old shaft heavily watered from near the top, an axle with drums was placed across: to one of these was suspended by a rope, a large tub, and from the other a rope was carried over the head wheels at the adjacent pit—the tub being at the top of one pit whilst the corfe was at the bottom of the other,—and *vice versa*. The tub thus suspended near the spring, was made to stand constantly full of water—on the ringing of a bell from the pit, the common intimation that the corfe must be drawn up, a catch is let go by the banksman, who pressing upon a brake to regulate the velocity of the machinery, suffers the tub to descend to the bottom, when a valve is opened and the water flows out, the corfe at the same moment being ready for landing at the other pit's mouth. An empty corfe being hung on, is just so much heavier than the empty tub, that the former descends while the latter is brought up and secured in the situation first described. This plan, which however can rarely be adopted, is free from many of those chances of accident to which other methods of drawing are liable, where the machinery, if not stopped exactly at the moment the corfe rises above the surface, and the reverse motion to lower it for removal accurately performed, will carry it over the head-wheels, and produce, as sometimes happens, fatal consequences. In Brinsley colliery, Notts., large buckets of water descending upon wheels along an inclined plane were at one time used to draw coals.

To facilitate the landing of the corfe or waggon, a strong wooden platform or trap-door is constructed, so as to admit of being brought over the pit mouth,

and locking with an iron bar, by the mere lifting of a lever, the instant that the ascending corfe has cleared its level, immediately after which, by a reverse motion of the machinery, the corfe is dropped upon the platform, detached from the hook, and drawn away to bank, or to the tram road. About Newcastle, two, and in some cases three, of the basket corves are drawn to bank at a time: they are suspended at short distances from each other on the rope, so that they occupy no more room in their progress up and down the shaft, than would be occupied by single corves. In some pits attempts are making to substitute large iron tubs for these baskets in raising the coals; at Braddyl's colliery of South Hetton, tubs, containing 24 cwt. each, are used. The term corfe*, is commonly applied to any shallow box, or like contrivance, used for bringing stuff up out of mines: in the northern collieries, where the coals are tender and often broken, they use a basket-corfe of a globular shape, and formed of twigs: it has a stout bent iron bow, to which the rope is attached, and is generally moved about on a small, low, four wheeled vehicle called a tram. In Staffordshire, and some other places, the coals are drawn out of the pit in

* The derivation is obviously from the Dutch *Korf*, a basket; that used in our collieries being made of hazle rods, somewhat in the manner of a hamper; the corf-bow was formerly for the most part of young seasoned saplings of oak, ash, or alder, of the thickness of three inches and about two yards long: it is now more commonly of iron. Great care is taken to keep up the corfe to its proper size; for it is liable to be beaten down daily against the sides of the pit, and in time, to lose nearly one-third of its original measure. It is the banksman's office to take care that the corves be properly filled: if any fraud be discovered, they are set aside, and the hewer is not paid for them. The corver, or maker of them, is paid in the following singular way: he is allowed a certain sum (formerly 4½d.) for every score of corves that are brought up the shaft, for which he is bound to find the pit with as many corves as are wanted, and also to keep them up to their exact measure, and in good repair.

buckets attached to sledge bottoms, similar to those of the tubs used in sinking; they are mostly made of sheet iron for the small, and of flat ribs rivetted at a distance from each other for the large coal. In the Yorkshire collieries, small waggons, made either of wood or of wrought iron, and generally in the shape of the large Newcastle waggons, are very generally used, as well in the underground operations, as in raising the coals from the pit, and also for drawing them to the carts, canal, or any adjacent station to which light cast-iron rails can be conveniently laid.

A shaft, up which coals are to be drawn, especially when sunk to a great depth, and of considerable width, is commonly not only walled and bratticed with boards, as already described, but when intended for the working of square corves or waggons, it is furnished with what are called conductors, an admirable arrangement, which, along with the appropriate corfe, was invented by the late Mr. Curr, and generally adopted in the extensive collieries about Leeds, Barnsley, and Sheffield. "These conductors," in the words of the patentee, "are nothing more than two or three upright rods of deal 4 inches by 3, bragged upon opposite sides of the pit, forming mortices or channels, by which the corves are conducted, being suspended upon cross-bars with rollers at their ends, which run within the mortices." In some places, these conductors consist of iron rods, bolted to massive beams at the pit bottom, and connected above to the head-gear by strong screws, which keep them tight and in their vertical position. In the use of single buckets, or even when drawing with the large bulging wicker-work corves, there is no occasion for guides of this sort, as, however the corves them-

selves may happen to turn about, their relation to the sides of the shaft and to each other remains unaltered. On the other hand, waggons in transitu, would, on account of their form, and the smallness of the space through which they pass, be liable to frequent and dangerous collision; but when placed in a sort of iron frame or chair, on the outside of which are friction wheels in contact with the wooden conductors, or sliding rings upon the iron ones, a steady uniform motion is given to the waggon and its crib, even when moving at the rate of one hundred and forty yards in half a minute: on the whole load being drawn up, and lowered upon the platform as above mentioned, the wheels of the vehicle first coming in contact with the board, it stands loose, and ready to be drawn away, and to be replaced by an empty one, an operation performed with surprising celerity. Connected with every pit in the neighbourhood of Newcastle there is a contrivance for screening the coals: in most cases it consists of a platform sloping at an angle of about 45 deg. from the raised bank about the pit toward the ground: at intervals are inserted grates twelve or fifteen feet in length, and about four feet wide, having the spaces between the bars more or less considerable according to the size of coal required to pass through. On each side of these grates, boards are placed to confine the coals in their course, and they are likewise boarded underneath, in such a manner as form the surface of spouts, by means of which the dust and small coal which pass through the bars fall into waggons placed for that purpose, as other waggons are placed outside of them for the reception of the screened coal. In general, however, since the repeal of the duty has

left it at the option of the coal dealer whether he will send large or small coal to market, or both together, the screens are mostly used merely to take the dust out of the coal.

In some situations, access to the coal workings is obtained, and the produce drawn out, by means either of a subterranean side cut from some navigable canal, or by a long tunnel laid with tram rails, and inclined more or less according to the elevation of the measures, and the relative situation of the sides of the valley or foot of the hill through which the perforation has to be carried. This description of entrance is called a *futteril*—footrail? There is probably no instance of its occurrence at the deep mines about Newcastle, though there are many in Yorkshire and other parts of the kingdom. Such road affords a convenient way for visiting the subterranean workings to those timid persons who might hesitate to descend the shaft by means of a corfe. Where there exists the convenience of cutting to the coal a gallery which shall incline from the workings to the day, if the distance be not considerable and the line direct, the laying down of double courses of flanch rails, enables the colliers to send out the full waggons so as to bring back again those that have been emptied, by connecting each set with a chain passing over a horizontal wheel at the head of the rail road. If on the other hand, the road inclines towards the coal, horses must be employed to bring out the waggons. A small canal, must, of course, be altogether on the dead level: in this case, the coals are either filled into long narrow barges at the water's head, or the corves are placed on a floating platform.

CHAPTER XI.

UNDERGROUND WORKS AND VENTILATION.

Methods of Carrying out the Underground Excavations of a Colliery—Broad and Long Work—Roads, Benks, and Gates—Plan of a Staffordshire Colliery—Ventilation—Theory of the Circulation of Atmospheric Air—Downcast and Upcast Shafts—Furnace—Simple and Compound Ventilation—Other contrivances—Description of Felling Colliery, Durham—Extensive and orderly arrangements—Fire Damp and Choke Damp—Scheme of Ventilation proposed by Mr. Menzies—Blowers or jets of Inflammable Gas—How got rid of.

HAVING described the method of sinking a shaft, and of putting down pumps, with the requisite working machinery by means of which the gaining, or as the parties concerned term it, *winning*, the coal is effected, it is proper in the next place to give some account of the underground operations. In getting the coal, the colliers do not, on coming at the seams, begin to hack and hew down at random as large a quantity as possible of the stratum within their reach;

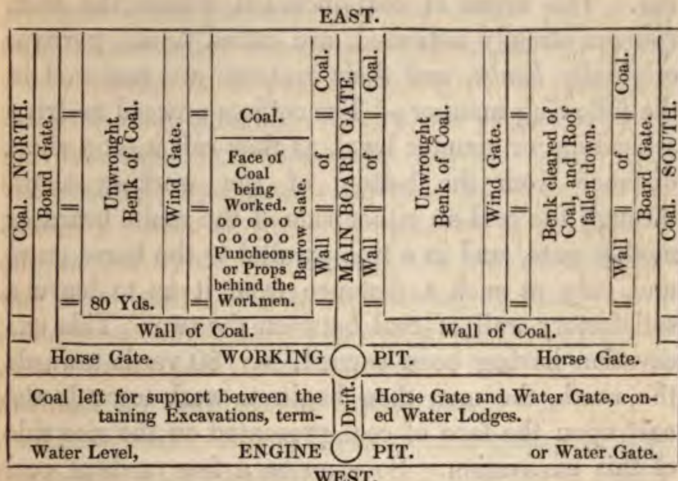
such a mode, although adopted to some extent in obtaining the Bovey coal, which lies comparatively near the surface, and commonly also in getting iron ore, would be utterly inadequate and ruinous if applied to the working of the deep seams of coal generally.

As the great object is to combine economy in extracting the greatest quantity of coal, with securing the personal safety of the pitmen—the latter, alas! not always possible—plans are laid down for underground operations, with as much accuracy as the ichnography of a complicated building or a city about to be erected on terra firma; and these plans are practically carried out in the workings to an extent* and with a degree of precision, the result of that perfect adaptation of the means to the end, which long practice and incessant attention have introduced into our collieries. There are two methods of carrying out the excavations in getting the coal—the *long* or broad, and the *short* or narrow methods; the former, by means of which nearly all the coal intended to be got is dug out at once, as is commonly the case in Yorkshire and elsewhere, where the strata immediately above and below the coal are hard and firm; the latter method is general on the banks of the Tyne and Wear, in which districts the coal itself is not only much more tender, but the over and underlying matters less to be trusted to, so that large portions of the seam are required to be left to support the roof.

The following underground plan, (in which of course there is no regard paid to exact proportion,)

* The space traversed by some of the works in Northumberland, Durham, and Cumberland, is amazingly great. The Howgill Colliery at Whitehaven, the property of the Earl of Lonsdale, extended over an area of 2300 acres—exceeding, in this respect, any other in the kingdom.

will illustrate one of the most ordinary modes of working in the Yorkshire collieries:—



Suppose the larger circle to represent the working shaft, sunk to the coal on its lower edge or dip towards the west; a commodious gallery is excavated upon the level bearing of the strata, and stretching in opposite directions from the bottom of the pit for the general conveyance of all matters to be drawn out; it is usually laid with cast-iron tram rails, along which the waggons or corves are drawn mostly by ponies; hence it is called the horse gate* or way. Parallel with this, another working is carried, upon which is sunk the engine pit, connected with the working shaft, and consequently with the horse gate and boards by a drift, and which being intended to serve as the common drain of the mine, is called the water gate. At right angles with these lines, and branching from the horse gate, first at the pit bottom,

* In Yorkshire the term "gate" is commonly used for a road or way.

and then at distances of 70 or 80 yards, other workings denominated boards or board gates are carried out. The areas of coal included within the open courses already indicated, are called *benks,* perhaps originally *banks,* and their contents are removed in the following manner:—The colliers proceed to drive a heading, or counter level, as they call it, at a short distance from the bottom of the working shaft, through the coal on either side of the main board or mother gate, and in a line parallel to the horse gate, and only at such a distance from it as to leave a satisfactory wall of coal between the two. This excavation having been carried, say 80 yards towards the north, the men then begin to work towards the east upon the face of coal presented on the rise side of this excavation. So soon as a few yards of coal have been cleared out, double rows of stout wooden puncheons or props are placed to support the roof*: the miners then proceed to get out another portion of the seam, until it becomes again necessary

* The appellations *roof* and *floor,* are given to those faces of the gallery or benk which are respectively over the head and under the feet of the pitman, while the sides are termed *walls.* The walls are generally nothing more than those vertical surfaces of coal which are left on either hand of the workmen, while the roof and floor are more frequently of stone, shale, earth, or other matter bounding the coal strata horizontally. Sometimes the roof appears to hang down for a short distance below its ordinary level, pressing the coal, and as it were squeezing it much thinner, especially in the middle of the space. These accidents of the roof pressing down nearer the pavement than it should be, and apparently squeezing the coal below its ordinary thickness, are of various dimensions. The lesser ones are like a wart or small protuberance on the under side of the stratum, which is the immediate roof of the coal; and this protuberance sinks down into the upper side of the seam of coal like the bottom of a great pot: it is called by the Scotch colliers a *bonnet case.* But these hemispherical depressions are not always of such small dimensions: some of them instead of being two or three feet, are as many yards; and occasionally they squeeze out one-third, at other times one-half of the thickness of the coal, thus forming in it, a basin shaped cavity.

to support the roof of the working: the puncheons* are, therefore, withdrawn, and replaced in advance of their former position—the roof of that part of the benk whence they are removed being allowed to fall down wholly or in part according to the quality of the rock composing it. One or two props, however, are left standing on the side next the board gate, and these in time form a passage called the barrow gate, by means of which the produce of the benk is discharged by the slit through the wall of coal into the board gate. When the working by these means has proceeded so far as to render it (the length of this barrow gate) inconvenient, a fresh slit is cut through the coal into the board gate.

These benks are usually worked in pairs; first, on each side of the mother gate to a distance of eighty yards: and then from parallel board gates opening into the general horse gate. Between the benks are likewise carried openings called wind gates, connected with an air or furnace pit in some part of the workings, to effect the ventilation of the mines. In first carrying out the excavations, prudence requires that the walls of coal indicated on the plan should be of considerable substance: but after the limit of the colliery has been reached, and on the abandonment of the works being resolved upon, those walls which were necessarily left to support the immense pressure from above, are often reduced at the last to a much greater degree of thinness, or even partially removed, so far as may be considered consistent with the safe retreat of the miners; there is generally, however, a

* These wooden pillars, which have usually between their heads and the roof of the mine a slab of board called a templet, are commonly of Scotch fir or larch of about 25 years' growth, or oak weedings of six or seven inches diameter.

deal of coal left in one way or other, often about one-eighth of the original mass, occasionally so little as one-tenth; but all this depends upon such a variety of circumstances, that no positive proportion can be mentioned as true of a variety of localities.

In some of the Staffordshire collieries, where the coal is of such an amazing thickness, immense sections are excavated with a comparative impunity of danger; pillars of coal being left at intervals to support the roof, which from its height, and the vastness of the workings carried on beneath it, presents, when lighted up, a most impressive spectacle. The following is a ground plan of the old Bradley mine, near Bilston. There are two shafts adjacent to each other A A. The horse gate is indicated by B B, and the narrower gallery, commencing at one of the pits and terminating in the open workings at C, is the air way. The stronger dark portion of the engraving is the rib, surrounding the work; D is a bolt hole or passage through the rib; and E E E are bolt holes stopped to cause a circulation of air through the work. F is a mass of coal left to support the shaft. The masses severally marked G, are the pillars which support the roof: the two smaller ones H H, are called by the miners "man of war" pillars. The excavated spaces in the direction

Fig. 27.

of the darts are merely called openings: those in the cross direction, stalls.

In the method of proceeding by *narrow* or *long work*, as practised about Newcastle, the excavations, as already intimated, are conducted on a much more complicated plan than those just described. To give some idea of the mode, it may be stated that long passages are cut through the coal, generally in a straight line: these openings are crossed by others at right angles, and 4 or 5 yards wide, the solid intervening masses forming rectangular pillars of coal 20 yards by 9, or, in some instances, square cubes of about the latter measurement on each side. It is in collieries of amazing depth, and containing many miles of excavation thus arranged, that perfect ventilation becomes an affair of equal difficulty and importance.

The efficiency of any system of ventilation conducted upon the ordinary principles, must depend mainly upon an attention to three particulars:—1, upon the opening of proper apertures for the admission of the atmospherical current; 2, on some method of accelerating, and by this means renewing, the volume of air in progress through the mine; and 3, in such a construction of the underground works, that every part shall be exposed to the ventilation. To illustrate this description—suppose the annexed diagram (*fig.* 28.) to represent a tube, having each end bent upwards at right angles with the horizontal portion, so as to form one level and two upright limbs. In this state, the tube will be filled with air throughout, just as it might be filled with water,

Fig. 28.

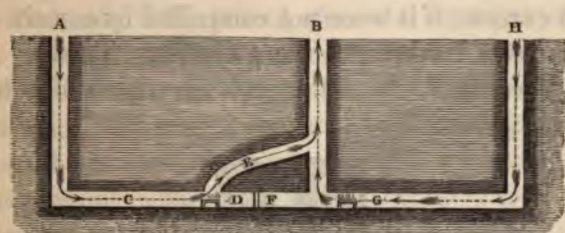
which would stand at the same height in each limb; of course, there will be no circulation*; so that should any circumstance occur to deteriorate the air in any part, especially in the horizontal portion, it would remain either stagnant near the spot where it was generated, or merely diffuse itself through the adjacent mass. And although the cause of deterioration might be of such a nature, that, by rarifying the internal volume in its vicinity, there would be a slight descent of fresh air, still, as the atmosphere would continue to press equally upon both apertures, nothing like circulation would take place, while the impure mass might be increased and concentrated. But if to the tube A we apply the flame of a lamp, or in any other way raise the temperature withinside, a new state of things instantly commences: a current of fresh air will rush down the tube B, and passing along the horizontal part C, will re-issue at A, thus ventilating, or, as it were, sweeping the entire passage: and this operation will go on so long as heat is applied at A. This is, in fact, nearly the entire theory of simple ventilation; B representing the *downcast* pit or shaft, by which the air descends into C, or working drift; after sweeping which, it rises to mix with the atmosphere, by the *upcast* shaft A. And

* In practice, however, the result is somewhat different, owing to the temperature of one part of the mine being raised considerably higher than the other, owing to the presence of the workmen and other causes. The instant a dip-pit is connected with a rise-pit, by a drift, a strong circulation of air like wind commences. If the air at the surface is at the freezing point, it descends the dip or deepest pit, freezes all the water upon the sides of the pit, and even forms icicles upon the roof of the coal; but the same air, in its passage along the boardways to the rise-pit, which is generally of less depth, has its temperature greatly increased, and issues from the pit mouth in the form of a dense misty cloud, formed by the condensation of the natural vapour of the mine in the freezing atmosphere. Mr. Bald, in Edin. Phil. Journ. vol. I. 134, where a series of investigations on the temperature of air and water in coal mines may be found.

if a colliery consisted simply, as is here supposed, of a single passage, however long or tortuous that passage might be, between one pit and another, no mode of ventilation could be better than this.

In practice, the following is the method of ventilation ordinarily adopted :—A (*fig.* 29.) is the down-

Fig. 29.

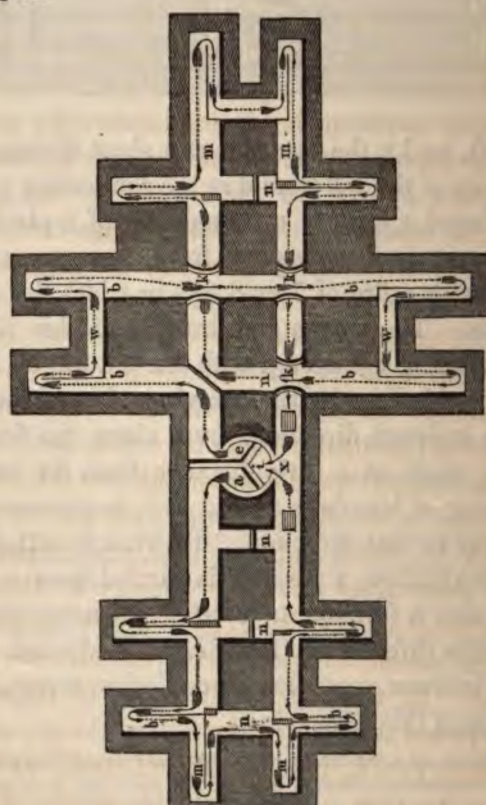


cast shaft, and B the upcast; at a short distance from the bottom of the latter, and in the connecting passage C, is placed a furnace D, consisting of a platform of iron bars, raised somewhat from the ground, and covered with a fire of 7 or 8 feet in width, by 12 feet in length. The smoke and draught of this fire, instead of being connected with the bottom of the pit B, are provided for by the carrying of an arched drift E, in an inclined direction, from above the fire-place into the shaft, at a little distance from the bottom.* A stopping of boards is placed at F, to prevent access of the air in that direction. In what is called compound ventilation, a passage is carried from G, where there is also a furnace, to another downcast pit H, in an opposite direction to the first. Wallsend, Percy Main, Hebburn, and Heaton collieries, were all ventilated upon this principle.

* In ordinary cases, the smoke from the underground furnace, or other works, is conducted by a lateral flue near the top of the shaft into a capacious chimney (*see fig.* 26. *p.* 204).

So far the apparent object is merely the ventilation of a single passage, or open space, between the pits; but as, by a law of pneumatics, the air has a tendency to rush from the downcast to the upcast shaft by the *nearest* openings, a large portion of every tract of workings carried forward by the *narrow* plan as above mentioned, would be unvisited by the fresh current, if it were not compelled by certain contrivances to traverse all the galleries. To shew how this is effected, *fig.* 30. represents a plan of a small

Fig. 30.



working ventilated by the compound method above alluded to, only that in this instance, instead of two downcast pits and one upcast, we have the three formed by bratticing or boarding a single shaft into three divisions, *a e i*—the two former letters indicating the downcast, and the latter the upcast, sections of the pit: near to the bottom of the latter are the two furnaces. The darts shew the direction of the two currents of air from their respective downcast pits, to the bottom of the upcast pit. The single lines in the figure shew the headway brattices; the double lines, the stoppings; *m m m m*, the winning headways, driven in the longitudinal direction of the coal, or in the line of its bearing; *n n n n*, the stentings, or opening between the double headways; *w w*, the walls, or passages between the boards at the end of each pillar; *b b b b b b*, the boards or passages driven in the transverse direction of the coal, and at right angles out of the headways; the boards are the places from which the daily supplies of coal are obtained. Just beyond the darts on each side of *x* are the two furnaces; *k k k* are three arches by which the current of air is carried over its former course.

In the old method of simple ventilation, the air, after descending the downcast pit, would, as before stated, pass in the shortest line to the upcast, but was prevented by doors and stoppings, and carried round by the extremities of the workings to the upcast shaft, without ever visiting the interior parts of the mine, in which, consequently, the air was left to stagnate. If, therefore, a discharge of inflammable gas happened to occur in the old workings, as it not uncommonly did, it soon diffused itself, and, along with the stagnant air, got into the course of the at-

mospheric current, rendering it nearly impossible for the workmen to prevent its exploding at their lights as they pass and repass along the working headways.

The inadequacy of this system, according to the testimony of Mr. Buddle *, was fully admitted; but no improvement was made, until the late ingenious Mr. Spedding, of Whitehaven, to whose memory our tribute of gratitude is due, suggested the idea of *coursing the air*; that is, forcing it through every passage of the several workings, or, in other words, making an air-pipe of every passage of the several workings of a coal mine: this sweeping of every part is effected by a complicated arrangement of stoppings and trap-doors; and so long as these are kept in order, and the passages open, it is almost impossible for there to be any accumulations of inflammable gas, owing to stagnation of the air in any part of the workings.

Besides the method of rarifying a volume of air in the upcast shaft, so as to promote ventilation by means of a furnace placed near the bottom, or as is sometimes the case, on the top of the pit, various other contrivances have been adopted, such as rarifying the air, by passing it through a large iron cylinder heated to a high temperature—the inflammable gases never igniting from contact with hot metal through which they may pass, though they would inevitably explode were they to come over an open fire. Exhausting and forcing pumps, worked by the engine, have sometimes been employed: Mr. Buddle prefers the former, because by the exhausting

* From whose interesting letter, addressed in 1813 to Sir R. Milbanke, Bart., on the various modes employed in the ventilation of collieries, these descriptions are derived.

system the atmosphere always presses on the downcast shaft; whereas by the contrary method, the current of air often recoils in *pinched air* courses. Emissions of steam and water have also been applied in ventilation—the former to aid the descent of cool air in the downcast shaft, and the latter to procure rarification in the upcast.

As further illustrative of the general course of underground working in the north, may be given the subjoined particulars relative to Felling Colliery, situate about a mile and a half east of Gateshead, in the county of Durham, and memorable as having been the scene, in 1812, of a most dreadful explosion of "fire damp," by which ninety-two human beings were suddenly hurried into eternity. The account is extracted from the Introduction to a Funeral Sermon preached on the occasion, and published by the Rev. John Hodgson, the intelligent historian of the county of Northumberland. The colliery alluded to is in the parish of Jarrow, celebrated as the birthplace of the "Venerable Bede," and still exhibiting the ruins of the monastery founded by him. The locality contains, in common with the adjacent neighbourhood, several strata of coal, the uppermost of which were extensively wrought in the beginning of the last century. The stratum called the High Main, noticed in a previous chapter, was "won," or come at, in 1779, and continued to be wrought till the 19th January, 1811, when it was entirely excavated. The present colliery is in the seam called the Low Main. It commenced in October, 1810, and was at full work in May, 1811. The working, or downcast shaft, called the *John Pit,* in accordance with the general custom of giving names to the

shafts, is 204 yards deep, and furnished with a *machine*, or steam engine, for drawing the coal, and with an engine called a *whim gin*, wrought by horses, and of use in letting down and drawing up the workmen when the machine chances to be crippled, or repairing; and when it lies idle on pay Saturdays and on Sundays.

The up-cast, or air furnace shaft, called the *William Pit*, is on an eminence 550 yards south-west of the John Pit, and is distinguished by a whim gin, and a lofty tube of brick work. This shaft is 232 yards deep. Over each pit two iron pullies, weighing 9 cwt. a piece, and over which the ropes passed, were suspended on a shaft-frame. The stoppings, which are commonly made of brick and lime, were in this colliery strengthened on each side with a wall of stone. The trap doors were made of stout wood; and each attended by a boy: they are seldom used but in the avenues leading from the working shaft to the workings.

In all large collieries, the air, as already intimated, is accelerated through the workings, by placing a large fire, sometimes at the top and sometimes at the bottom of the upcast shaft; in the latter case it is usually connected with the pit, serving as a chimney, by an arched gallery of brick, which in this colliery was about 50 feet in length, the furnace being six feet from the bottom of the shaft. The course of air, in the works at Felling, was merely up and down some of the principal boards in use, until it traversed the newly formed *sheth*, or set of workings; and after fanning them, found its way down a passage called, from it use, the crane board, after which it ascended into the furnace, and thence, charged with noxious vapours, into the open air.

It is assumed in the previous remarks, that the purity and wholesomeness of a coal mine has no reference to its depth, though this has been disputed, on the ground that the gas is more condensed, and, therefore, more explosive in deep than in shallow mines. If, however, the air be conducted in sufficient quantity through all parts of a mine, as above described, and no falls of matter from the roof occur to prevent its visiting every quarter, the old excavations, which are called *wastes,* will be as constantly ventilated by as pure air as the boards in which the men are at work—each part of the mine will be uniformly wholesome; but when obstructions occur, and are not speedily removed; when the fire in the furnace shaft is neglected; or when care has not been taken to place the stoppings and trap-doors in proper places, or the trap-doors are carelessly left open, or stoppings fall down,—in all these cases accumulations of *fire-damp* (called *stythe* by the colliers), immediately commence in places deprived of the atmospheric current, and continue to train their dreadful artillery, and grow strong in danger, till the *wastemen,* or ventilators of the mine, discover them, and wash them off, or they ignite at the workmen's candles.* Blasts occurring in stagnations, as in the face of one or two boards, though they generally scorch the persons in their way, seldom kill them; but when the air has proceeded lazily for several days through a colliery, and an extensive magazine

* To prevent the accumulation of the fire damp, it was formerly a practice with the workmen to set fire to it by the flame of a candle; using the precaution of lying prostrate on the ground during the explosion; but this dangerous practice has long been relinquished, except in some collieries where the quantity is so inconsiderable as to render the lighting it mere matter of amusement.

of fire damp is ignited in the wastes, then the whole mine is instantly illuminated with the most brilliant lightning—the expanded fluid drives before it a roaring whirlwind of flaming air, which tears up every thing in its progress, scorching some of the miners to a cinder, burying others under enormous heaps of ruins shaken from the roof; and, thundering to the shaft, wastes it volcanic fury in a discharge of thick clouds, of coal, dust, stones, timber, and not unfrequently limbs of horses.

But this part, though apparently the most terrible, is not the most destructive effect of these subterraneous thunderings. All the stoppings and trap-doors of the mine being blown down by the violence of the concussion, and the atmospheric current being for a short time entirely excluded from the workings, those individuals that survive the discharge of the fire damp are often instantly suffocated by the *after-damp*, which immediately fills up the vacuum caused by the explosion. This deleterious vapour is called *choke-damp*, and *surfeit* by the colliers, and is the carbonic acid of chemists. While the mine is at work, it lies sluggishly upon its floor, and suffers the atmospheric air, as a lighter fluid, to swim upon it: fire-damp, being the lightest of the three, floats upon the atmospheric air, and thereby occupies a space, according to its present quantity, nearest the roof of the mine. A detailed account of one of these dreadful explosions, and of its fatal consequences, will occur in a subsequent chapter. The description of Felling Colliery is adopted here, not only as giving a very clear idea of the general character of the underground arrangements of the coal mines of Northumberland and Durham, but also, because it was con-

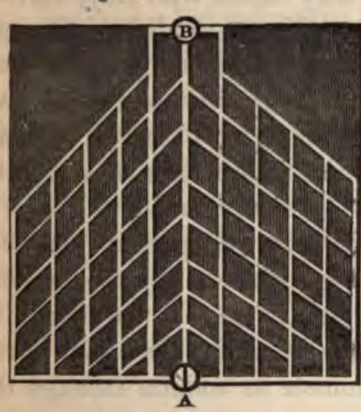
sidered by the workmen a model of perfection in the purity of its air, and orderly arrangements. The coals from the sheths or working boards on each side of the William Pit were conveyed in strong wicker baskets or corves, to the crane on *trams,* a narrow frame-work of wood mounted on four low wheels: this work was done by *barrowmen,* and *putters,* some of whom are men, and manage a tram singly, by going behind it and pushing it forward; these are called *hewing putters,* or *headsmen*: the others are two to a tram, and are called *headsmen* and *foals,* the former of whom pull before at a rope called a *soam,* and the latter push behind with their shoulders: boys about 15 or 16 years old are employed in this department of the colliery. Horses are likewise used in drawing the coals along those lines of the working, where there is sufficient room for them. The use of the crane, in one of the boards mentioned before, is to lift the loaden corves off the trams, upon waggons which differ little from the trams, except in their being larger and stronger. From the crane, about four waggons, each carrying two corves, and chained together, were taken to the crane board, by means of an inclined plane, on which the empty waggons were drawn up by the descent of the loaded ones, both sets being attached to a chain passing over a horizontal wheel, connected by machinery with a brake, in the charge of a *brakeman,* and adapted to regulate the velocity of the waggons. From the bottom of the inclined plane, the coals were conveyed on the same waggons to the John Pit. This inclined plane was reckoned equal to saving the daily expense of at least 13 horses—the whole concern, at the period immediately preceding the catastrophe afterwards mentioned,

wore the features of the greatest possible prosperity, and no accident, except a trifling explosion of fire-damp, slightly burning two or three workmen, had occurred. Two *shifts*, or sets of men, were constantly employed, except on Sundays. Twenty-five acres of coal had been excavated. The first shift entered the mine at four o'clock, A. M., and were relieved at their working posts by the next, at eleven o'clock in the morning. The establishment it employed under ground, consisted of about 128 persons, who, in the fortnight, from the 11th, to the 25th of May, 1812, wrought 624 scores of coal, equal to 1,300 Newcastle chaldrons, or 2,455$\frac{20}{36}$ London chaldrons.

In the Annals of Philosophy for April 1816, there is an interesting communication on the ventilation of coal mines, by Lieut. Menzies, of Durham. The object of the writer is to recommend a method of working in which, the floor and roof of the mine shall be inclined, conformably to the dip of the strata, which may range perhaps from one in five to one in twenty; though about one in twelve, or nearly the mean of these extremes, may be mentioned as corresponding with several collieries on the Tyne and Wear:—and moreover, it is proposed that the lines of working, instead of being rectangular as represented in *fig*. 30, shall be diagonal, in order that the air may circulate more freely. It is not necessary in this place to go into the details which are given at great length in the work above named—and more especially did this omission appear immaterial, as on asking a highly respectable manager of a colliery, to whom the writer of these pages has been indebted for several valuable particulars, whether such a mode

of working was in any instance adopted in the county of the projector's residence, the reply was :—"I know of no case where the workings are driven obliquely: he could only be a theorist who would recommend such a plan." The scheme of Mr. Menzies will be at once comprehended from the sketch, (*fig.* 31.) representing a small tract of workings, in which the straight parallel lines on each side the main drift between the two pits A and B, are the headways, and the oblique lines crossing them, so as to leave the pillars of coal of rhomboidal form instead of being parallelograms as in ordinary cases, are the working boards: so that, supposing the downcast shaft A to be 180 yards deep, and at a distance of 1200 yards from the upcast B, which is 80 yards deep,—the strata rising at the rate of one yard in twelve—all the side workings will also rise according to their angle with the direct line of the hading or dip, towards the upper pit, and thus discharge their contaminated air.

Fig. 31.



In concluding this Chapter, it may be added that the evolution of fire-damp in mines is in general gradual and slow: but not unfrequently great discharges of it are made into the workings, from what are termed *blowers*. A blower is a fissure, or small opening through which the stream of inflammable

gas rushes into the mine, in great quantity, and with considerable noise; as if the reservoir from which it comes were under the pressure of a head of water, which may in some instances be the case. These jets are sometimes met with in the most perfectly ventilated collieries, where they excite no apprehension: and we have known the colliers collect the gas in large bottles, which they closed with clay, carried them home, and there, making a small hole through the clay, have lit and used them as portable gas-lamps. Blowers are said in general to proceed from the roof, but are sometimes also observed to issue from the floor of the mine. The stream of gas, however strong at first, is generally found to diminish gradually and then to cease altogether. When, however, the discharge is either so great or so continued as to be dangerous, it may be led by a tube the nearest way to the upcast shaft; some part of the tube being heated to promote its motion through the conduit*.

A curious method was sometimes formerly employed in the Leicestershire mines to expel the car-

* Perhaps nothing tends to give a stronger or more impressive idea of the terrible proximity to danger in which the pitman pursues his labour, than the manner in which the carburetted hydrogen is evolved above ground at one or two of the Newcastle pits, and was formerly the case also at Workington and Whitehaven. Not far from Wallsend church, a four inch pipe connected at the pit bottom with an insulated portion of coal strata extending about four acres, is carried up as high as the head gear: from the orifice of this tube there constantly issues an ignited stream of gas forming a flag of flame, at least eight or nine feet in length. At night—and indeed during the day—this is conspicuous to a considerable distance; and on approaching the spot, such is the force with which the inflammable vapour is emitted, that it produces a sound like the roaring of a blast furnace. The immense natural gasometer in which this tremendous agent is collected, supplies the flame at the rate of eleven hogsheads per minute! There is a similar emission at Willington colliery—the discharge is most vehement when the wind blows from the south east.

buretted hydrogen. In short distances from the main current of ventilation, "a workman crouched upon all fours without a light, keeping his head low to prevent breaking the gas, or a mixture of it; and fastening a hook with a string through it in the roof at the extremity of the opening. He then returned, in the same manner, to the entrance with the two ends of the string in his hand: to one of these ends he fastened a lighted candle fixed in clay on a board—with the other, he drew the candle to the extremity in good air, and finally raised it to the hook in the roof, when its flame ignited the gas at that point, upon which a violent rush of atmospheric air immediately took place."* The introduction of the Davy lamp has, however, mostly superseded this perilous practice.

* Geol. Facts, p. 26.

CHAPTER XII.

GETTING THE COAL.

Ideas of unpleasantness and danger associated with Coal Pits in general—Few persons like to descend to inspect the subterranean workings—An interesting sight to the Visitor—Impressions experienced in traversing the deep fiery mines about Newcastle—Plan of removing the pillars which support the roof—Crushes or creeps—Working crept Coal—Appearance of the Pitmen underground—Steel mill—Use of Horses—Anecdote—Employment of Females—Implements used by the Collier—Fractures of the Coal—Backs, cutters, and partings—Methods of breaking down the Live Coal—Attempts at the introduction of Machinery.

FROM what has been stated in the preceding Chapter, a tolerably accurate idea may be formed of the underground economy of a coal mine in its general scope. It will be proper, however, to describe some of those dangerous but not unusual combinations of working by means of which a still greater proportion of the entire coal is obtained, and also to go a little more into detail relative to the actual operations of the colliers. As exhibitions, the minia-

ture model of a coal-work in one of the fashionable Bazaars, and even the Thames Tunnel, have attracted the attention of parties in the metropolis; while few persons, actuated by curiosity merely, have the resolution to descend a coal-pit, whether they happen to be residents or visitors in the colliery districts: this circumstance is perhaps generally attributable partly to the prevalence of a vague notion of danger, and connected therewith, the necessary unpleasantness in most instances, of traversing the excavations amidst the dirt and moisture commonly met with in such places*. Yet these considerations and inconveniences overcome, and they are often greater

* The collieries belonging to Earl Fitzwilliam at Elsecar and Rawmarsh, near Rotherham, are carried on with great spirit, and the whole of the arrangements for working them are on a scale of great magnitude; at the same time they are carried out with a degree of care and effect not surpassed in that part of the country. The workings are not only approached by means of the drawing shaft, but also by a futteril or subterranean way, so that timid persons, who might hesitate to allow themselves to be let down by means of the steam-engine, need be under no apprehension about entering by the inclined gallery. There is, moreover, little or no fire damp, so that the colliers work with open lamps; and so clean and commodious are the board ways, in many parts, at least, that the ladies from Wentworth House, sometimes go down to witness the operations, and more particularly to see the impressions of organic remains with which some portions of the strata abound. The roof is beautiful, not only on account of its being in some places richly embossed with lepidodendritic impressions, but because it is for the most part, as dry, compact, and even as the street pavement itself. The comfortableness of the board-ways underfoot, has been materially lessened, since the occasion when it was necessary to inundate the works with water from a neighbouring reservoir, in order to extinguish the burning of the beds of coal which had been wilfully set on fire. Dirty, however, as was the floor of the mine in many parts, owing to the cause first assigned, when the author went in a few days previous to writing this paragraph, (June 1835), it was by no means impassable to curious visitors. The entrance of the footrail consists of a neat front with two lodges of hewn stone, having between them an iron gate. One of the shafts is called the Royal William Pit, from the circumstance of his present Majesty having once, when Duke of Clarence, descended, along with some other illustrious guests of Earl Fitzwilliam, to inspect the workings. This august personage, is also said, previously of course to his accession to the throne, to have once descended into the deep workings of a coal mine at Newcastle.

in imagination than reality—there are few sights more striking to an eye unaccustomed to subterranean mining operations than are presented by those immense caverns, or apparently interminable galleries, in which the pitman pursues,

> "Howe'er the daylight smiles, or night-storms rave,
> His dangerous labour, deeper than the grave;
> Alike to him, whose taper's flickering ray,
> Creates a dubious subterranean day,
> Or whether climbs the sun his noontide track,
> Or starless midnight reigns in coif of black;
> Intrepid still—though buried at his work,
> Where ambushed deaths, and hidden dangers lurk."

Besides the rarer occurrence of those ancient vegetable forms described in previous Chapters, the curious visitor will commonly be interested by the more recent manifestations of organised existence. In the damp recesses of the mine, several species of the fungus family make their appearance: as these are mostly beautifully white, sometimes filamentous, at others like tawed leather, they contrast strikingly with the sombre aspect of the coal from which they shoot. Not only are there various species of fungi met with in the forsaken workings of old coal mines, but sometimes mosses, especially the *Rhizomorphaceæ*, or root moss.* Efflorescences of mineral matters

* In the coal mines in the vicinity of Dresden, the *Rhizomorpha phosphorea* are said to be so abundant and so luminous, as even to dazzle the eye by the brilliant light they afford. Mr. Erdmon, the Commissioner of Mines, thus describes the phosphorescent appearance of the Rhizomorphæ in one he visited:—"I saw the luminous plants here in wonderful beauty; the impression produced by the spectacle I shall never forgot. It appeared on descending into the mine, as if we were entering an enchanted castle. The abundance of these plants was so great, that the roof and the walls, and the pillars, were entirely covered with them; and the beautiful light they cast around almost dazzled the eye—it resembled faint moonshine, so that two persons near each other could readily distinguish their bodies. The lights appear to be most considerable when the temperature of the mines is comparatively high."—*Burnett's Outlines of Botany, p.* 165.

of considerable interest sometimes occur—in minute capillary masses frequently: occasionally, however, judging from specimens in the museums at Newcastle and other places, very fine crystals of sulphate of lime are found in the abandoned galleries of Felling colliery; "teaching," as was lately remarked,* "important truths as to the power and action of what have been called 'diurnal' geological causes."

But if courage be required to enter a coal mine at ordinary depths, it is in descending the frightfully deep pits in the neighbourhood of Newcastle, that sensations bordering on the awful are inevitably experienced; and in traversing at such profound depths the endless galleries into which the shafts ramify, the visitor is struck by the perfection of plans adapted to lessen, as much as possible, the risk which the pitmen run in situations where the great value of the coal induces them to get it as completely as possible. On the other hand, the vast caverns formed in getting the thick Staffordshire coal, exhibit on a much more striking scale the combined operations of the miners, from the space which, when artificially illuminated, the eye commands at once; at the same time that persons may move about more commodiously, and also with fewer apprehensions of danger from explosions or foul air. A large but indifferently executed print published some years ago in Staffordshire, represents in a striking manner several of the operations connected with getting the ten-yard coal in the old Bradley mine, near Bilston.

But whatever be the dangers or difficulties that may be encountered in carrying out the first workings, according to the plans already described, in which

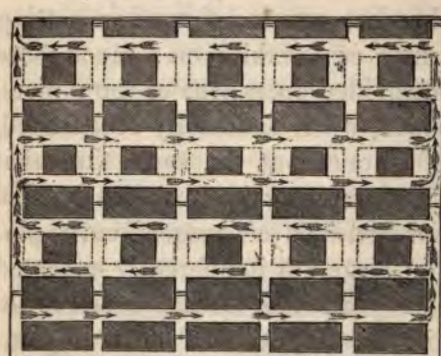
* In Report of Yorkshire Phil. Society, 1835.

numerous pillars or props are left standing to support the roof, how largely must such dangers and difficulties be increased, when the intrepid miner proceeds, as is often done, to work out the material of those supports!

It may be proper to premise, that in the deep northern mines, where the floor is often as soft as the coal is tender, there sometimes occur those striking movements which are technically called *crushes* or *creeps*, or in Scotland *sits*. A creep is a certain protrusion or bursting upwards of the floor of a mine, owing to the small extent, and consequent liability to sink, of the bases of those pillars of coal which are left to support the roof during the excavation of so much of the seam as appears compatible with safety to the pitman.

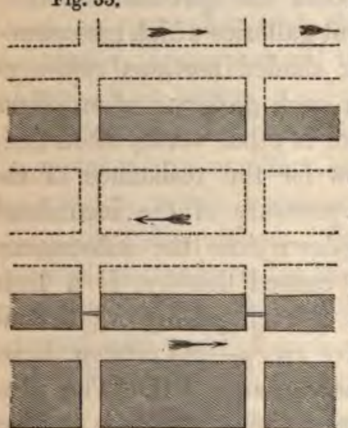
Suppose the annexed diagram (*fig*. 32.) to represent a field of coal: the oblong dark shaded portions will shew the pillars, and the white spaces the extent from which the coal was dug out, in the manner described in the preceding Chapter, and before the working of the pillars was attempted. The whole of these pillars were considered necessary for securing the roof, and no attempt was made to reduce them, previously to 1795, from the apprehension of producing a creep. In that year,

Fig. 32.



when the Walker Colliery became exhausted, as to the main seam, an attempt was made at partial working, by removing one half of every alternate pillar, as shewn in the cut. By this means 55, instead of only 40, per cent. of the entire coal was obtained; the remaining 45 per cent. being still left in the pillars, and consequently lost. The double lines in the transverse openings represent the air stoppings of brick-work, and the darts shew the direction of the current of air. In 1810, another improved system* was introduced—first in the working of Percy Main Colliery. The coal mines were believed to be exhausting so very rapidly, that an attempt was made by which every intermediate pillar was entirely taken out, and also a portion of the adjoining ones, as shewn in the annexed diagram (*fig.* 33). By this plan, and by working in small divisions, the daring workmen succeeded in obtaining, from the fiery collieries on the Tyne, about eighty or ninety parts of the coal out of one hundred; still the ultimate effect was, that creeps took place; the danger was increased, and great loss of coal was the consequence.

Fig. 33.



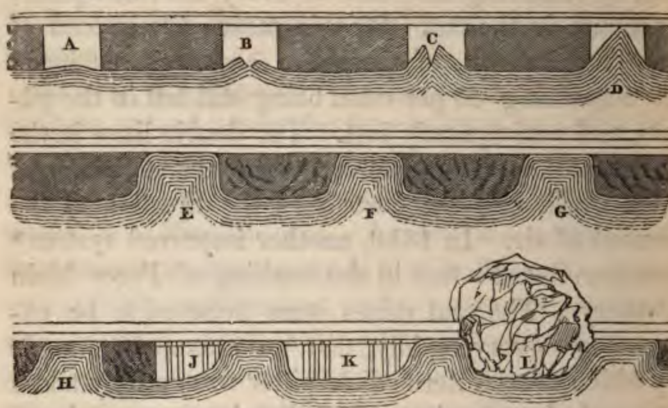
The following diagram† (*fig.* 34.) explains the creep in all its progressive stages, from its commence-

* Mr. Buddle's Evidence.

† Taken from a copy of that exhibited by Mr. Buddle in his Evidence before the Committee of the House of Lords in 1830; the description of the progress of a creep is derived from the same highly respectable authority.

ment until it has completely closed all the workings, and, as commonly happens, crushed the pillars of

Fig. 34.



coal. This section supposes the spectator standing on the level of the different galleries which are opened in the seam. The dark shaded portions represent the coal pillars between each gallery: when those are weakened too much, or in other words, when their bases become too narrow for the resistance of the pavement below, by the pressure of the incumbent stratification, they sink down into the substratum, and the first appearance caused thereby, is a little curvature in the bottom of each gallery A; that is the first symptom of active creep—the pitmen, however, more commonly *hear* than *see* it. The next stage is, when the pavement begins to open, with a crack longitudinally B: the third stage of active creep is when the crack is completed, and it assumes the shape of a metal ridge C: the fourth stage is that in which the metal ridge reaches the roof D. In the next stage the peak of the metal ridge becomes flattened by pressure against the roof, by means of

which it is forced into a horizontal direction, and becomes quite close, E: just at this moment, the coal pillars begin to sustain part of the pressure. In the next stage, F, the pillars take a still farther part of the pressure; and lastly, the crush is said to become dead or settled, G. This final stage is complete when the metal or factitious ridge, formed by the sinking of the pillar into the pavement, bears, in common with the pillars of coal on each side, the full pressure, and the coal becomes crushed or cracked, and can no longer be worked except by a very expensive and dangerous process.

The introduction of the Davy lamp, however, has enabled the intrepid miner even to work out the portions of coal thus fearfully locked up by creeps: an inspection of the latter portion of the foregoing diagram, in connexion with the following, will enable the reader to comprehend the nature of the undertaking. The letters F G in the diagram, represent the coal completely crushed, and the roof resting on the metal ridges or pillars, as already described, being the state in which, previous to 1815, the mine was commonly relinquished. To get the remaining coal, the first process is to dig through the rubbish, after which, to prevent the exfoliation of the roof, it is propped with posts of timber, as shewn at H in the cut. This method is pursued until the whole of the coal is extracted, when the props J are removed, if safe to do so, and the superstrata break down *en masse*, in what the miners term a *goaf* K, and fill the space previously occupied by the seam of coal. In some cases, the *thrust* or downfal of the strata, which takes place in a district where the crept pillars have been entirely worked out, not only causes vast frac-

tures in the superjacent mass, but occasions, moreover, a considerable subsidence of the surface.

Such are the methods of carrying out the workings —more or less intricate and dangerous—of our coal mines: it remains to describe the actual progress of getting the coal, which is the immediate object of the present Chapter. The pitmen themselves are in most collieries dressed loosely in flannel clothes, though, from the elevated temperature of the mine, they are generally almost naked above the waist. In all cases, their dress and their bodies soon become so covered with sooty matter from the pulverisation of the coal in working, that they present a peculiarly grim aspect; and this effect is not a little heightened by the flaring of their lights, and the dark hue of the mine on every side. In some collieries they use small, and in others thick candles; more commonly oil lamps; but generally in the north, and where fire-damp abounds, Sir Humphrey Davy's wire-gauze lanthorn (which will afterwards be described) is adopted, instead of the flint and steel mill formerly employed in the dangerous workings.* Of course, where gunpowder is used, candles are also in use; as any collections of gas that would explode by the flame of the latter, would as certainly be ignited by the firing of the former.

Fig. 35.

The figure annexed is a side view of a steel mill of simple construction. A B is a frame of iron, in which the brass cog wheel C and

* In the Life of Brownrigg, the steel mill is said to have been the invention of a Mr. Carlisle Spedding, of Whitehaven, to whom the same authority attributes the contrivance of wooden waggon-ways.

the steel mill D, are fixed by their axles, so that the teeth of the former take into the pinion E of the latter, thus producing a rapid revolution of the steel periphery, against which the piece of flint is applied, and a stream of sparks elicited. The machine is put in motion by means of the winch handle F. These mills vary in size, as well as in form; in that from which the sketch was taken, the wheels were about six inches in diameter. It is sometimes fixed upon the breast of the pitman, and there worked by him; in other cases, it is placed in the most convenient situation for use.*

Horses, as intimated in the last Chapter, and in some places asses, on account of their size, are employed in the workings to draw the trams, when loaded with the corves—or *skips*, as they are called in Staffordshire—by the putters or hurriers: in some collieries, the number of horses kept in stables underground is very considerable; and as they are rarely or never drawn out, and are, therefore, constantly deprived of the advantages of daylight and fresh air, they soon lose their sight. A misunderstanding of some statement which had probably been made to him concerning the destiny of cattle thus employed, once led Mr. Cobbett to commit a ludicrous blunder: this gentleman had been lecturing at Newcastle and adjacent towns in the autumn of 1832; in the interval of a week or two, the inhabitants of the neighbourhood were not a little surprised to read, in the "Political Register," the following paragraph:—

* The expense formerly incurred in the article of steel mills seems almost to exceed belief. Dr. Clanny once stated, that in a single working of a colliery in the neighbourhood of Sunderland, the expense of steel mills was about £30 every fortnight—so many of them having to be kept at work at a time to give any thing like a sufficient light.

"Here is the most surprising thing in the whole world; thousands of men and thousands of horses continually living under ground: *children born there, and who sometimes never see the surface at all, though they live to a considerable age*"!! Cobbett seems to have applied to the colliers circumstances which might have been related to him concerning the horses. To the credit of the directors of collieries on the Tyne and the Wear, there are no females employed in the workings: this, however, cannot be affirmed concerning the Staffordshire, Shropshire, and other coal mines: indeed, only within a few weeks of the writing of this notice, three young women, sisters, were killed by an explosion of fire damp; and another in consequence of accidentally getting her foot entangled in the ascending corfe. In Scotland, the employment of the weaker sex in this laborious and disgraceful manner, is very common*—as, indeed, it

* In the Scotch colliery of Gilmerton, in Mid-Lothian, which is nearly 90 fathoms in depth, the coal, which is 5 feet thick, and lies at an angle of 40° with the horizon, is borne upon the backs of women and girls from the various workings, in wicker creels, which are fitted to the back, and steadied by a leathern strap passing round the forehead. The regular load of a good bearer is from 12 to 14 stones, and the remuneration about one shilling per day. These bearers have for lights small oil lamps hooked into the front of their caps; their dress the coarsest woollen; and they generally use a very short stick, as a steadier to their precarious footing. The sensitive mind revolts at the idea of females being so employed; and it is not easy to listen to any thing like an apology for the adoption of such a practice. "The bearing system," says Mr. Dunn, "so peculiar to the coal mining of Scotland, seems to have originated in working the Edge seams; and when the difficulty of applying any other means comes to be considered, necessity would appear to plead strongly for such a practice, especially at a period when the means of sinking to the deep Flat coals was so imperfectly understood; but it is difficult to account for a system so replete with poverty shame, and demoralization, and moreover, so destitute of real economy, being persisted in throughout the neighbouring flat collieries. In Sheriff Hall and Edmonstonstone, not less than 250 or 300 bearers are constantly employed."—*Trans. Nat. Hist. Soc. Northumb, vol. i. p.* 171. This was written so recently as 1830, but as tram-roads were then beginning to be intro-

formerly was in this country, women and children bearing forth the coals on their backs, or at least carrying them from the workings to the bottom of the shaft.

The working tools of the collier are few and simple, consisting chiefly of different forms of that very efficient implement the *pick,* being a sort of small mattock with both ends of the head pointed, and perhaps derived from a somewhat similar tool of great antiquity, figured among the Egyptian hieroglyphics. To the pick may be added small crowbars, iron hammers, mandrils, and wedges.

It is worthy of especial observation, in regard to the cubical structure of the coal seams in general, how beautiful a system of subordinate fractures conduce to facilitate the separation of the mineral masses by means of the implements of the miner. Parallel to the stratification of the seam, so as to divide it into thick lamina, run what are termed *partings,* or spaces commonly filled with a sooty matter; there are, in the next place, successions of vertical cracks cutting through the stratum in the direction of its bearing line or level, or, according to Mr. Mammet, generally observing a north and south polarity: these separations are called *backs* or *slines,* or by the Yorkshire colliers *bright-heads,* from the coals separating at these cleavages with clean and highly polished surfaces, except when, as often happens, the complanatory lustre is covered with a rusty-looking scale, or with the well-known white sparry concretion, consisting for the most part of carbonate of lime, derived from the infiltration of ferruginous or calcareous

duced, we may hope, for the sake of humanity, they will by this time have, to a large extent, superseded so unbecoming a species of labour.

water; besides these fissures, there are others passing through them vertically at right angles, and appropriately denominated *cutters;* so that by means of this compound system of natural fractures, the coal, under favourable circumstances, easily breaks down in parallelopipedal masses. Of course, the structure of the coal formation in different places exhibits many and important deviations from uniformity in this respect.

In proceeding to get the coal, the collier, whenever he can do so, works upon the face of the bed,—i. e. if the seam dips towards the east, he would, if in other respects convenient, work towards the west, or otherwise in the opposite direction, and not, unless under peculiar circumstances, in the direction of north and south, or upon the end of the coal. The advantages of this mode will be obvious in connexion with the explanation given above: the opposite course would manifestly be little less absurd than that of a person who, having to demolish a mass of masonry, in which all the bricks were laid lengthwise upon and in courses parallel to one another, should pursue his operations in that direction which only presented the ends of the bricks.

In working upon such a face as that above described, the men in the boards or stalls first undermine the mass, by hewing out a portion next the thill or floor of the mine. This operation is called *kerving*, or *holing under;* and it is the object of the workmen to waste as little of the coal as possible, particularly where the seam is thin and of equal quality throughout; in some instances it has a sole or footing of inferior value, which is the more cheerfully sacrificed. In the next place, deep vertical

grooves are cut on each side of the mass intended to be brought away, so as to define its size: it is then broken down, either by means of wedges or by the force of gunpowder; the former is mostly the method adopted in Yorkshire and various other places; the latter generally prevails in the deep mines of the more northern counties. In blasting, a hole is made about a yard in depth, and the shot inserted near the roof or top of the working; and as the effect of the explosion is much more considerable when it can be made to act mainly in the line of one of the vertical back fissures above described, the collier, whose habit it is to set these shots, acquires such an exact perception of the nature of the substance which he penetrates, that he can generally pronounce when his chisel reaches one of these polished faces.

It is not uncommon in working fiery seams of coal, for a jet of gas to issue at the hole which is driven for setting the shot; this takes fire at the lamp or candle, and if suffered to extend, might lead to serious explosions: it is generally, however, unless a considerable reservoir has been tapped, readily *doused* or beaten out with a bag kept for that purpose. In some cases, when the gas is not easily extinguished, a small cannon is fired, and the concussion caused will sometimes produce the desired effect. Besides the danger always attendant upon the irregular ignition of the gunpowder and emissions of gas, there is another and sometimes fatal casualty to which the miner in this department of his labour is liable, owing to the sudden and unexpected separation at the slines of a deep facing or wall of coal from the mass, when the under portion has been removed, or during that operation.

The nature of these underground operations precludes, in general, the substitution of machinery for direct manual labour, though various experiments have at different times been made with reference to that object. One of the contrivances for this purpose best known in the north, was a machine called, from the inventor, "Willy Brown's Iron Man," which was introduced into Willington Colliery about 60 years ago. This agent was to have done the work of a giant, but as he required a strong man to work him, and another to direct his blow, he was soon laid aside. In addition to the above, it may be mentioned that the late Mr. Wood, of Newcastle, invented a machine to drill, and drive the wedges into the coal, in order to bring the top down without the aid of gunpowder. This contrivance consisted of a sort of elevated railway, along which was pushed a large and heavy iron ram, managed by two men, which struck the drill or chisel so as first to open a space of a few inches, after which the wedge was introduced and driven up by means of the ram, until the mass was brought down. It was calculated that this method would spare that shaking, and consequent breakage of the coal, which take place when gunpowder is used. One cargo of coals was wrought by this means in the colliery of Messrs. Brandling at Gosforth, and sent to London; but the extra expense of working, and cost of machine, rendered it like Willy Brown's Iron Man—a thing of curiosity rather than of use, and it has long been laid aside. Some attempts have also been made to bring down the coal by means of forcing into the mass immense taper screws.

CHAPTER XIII.

UNDERGROUND ACCIDENTS.

Various dangers to which the Collier is exposed—Falling of matters from the roof of the Mine—Cauldron bottoms, bell moulds, and bleas—Irruptions of Water—Instances of Flooding—Occurrence of Subterranean Fires from natural, accidental, and wilful causes—Explosions from inflammable Gas—Dreadful Accident at Felling Colliery—Details of the Catastrophe—Fire Damp and Choke Damp.

THE dangers with which the Collier has to contend, and the accidents to which he is liable while pursuing his gloomy avocations, may be comprised generally under three classes, namely—1. Matter falling from the roof, or some other part of the mine; 2. Irruptions of water; and 3. Fire damp. Instances of the former kind are comparatively rare, and always of local occurrence: so that although large quantities of shattery roof may sometimes fall down, and suddenly bury the miner, or masses of coal, inadvertently loosened, may occasionally descend and crush him to death, accidents from these causes are very infrequent, as they are generally to be avoided by the

exercise of due precaution on the part of the workmen. Indeed, when we reflect upon the manner in which the benks and boards are excavated, and also take into the account the enormous masses of superincumbent matter constantly impending overhead, and the sufficient cohesion of which can be, in many instances, but imperfectly ascertained,—our surprise need not be, that we now and then hear of the occurrence of a fatal casualty from this source, but rather, that we hear of so few. The roof of the coal is in some mines rendered highly dangerous by the occurrence of what are sometimes called "cauldron bottoms"*; in others, it becomes exceedingly shattery and infirm, owing to the profusion of casts of stems intermixed with its substance. As these fossils have commonly a glossy coating of coal or jet, they sometimes suddenly drop out, to the imminent danger of the workmen, who, however, are generally aware of the impending evil. In the pits about Bristol, a sometimes fatal annoyance of this character is occasionally encountered. In the red sandstone above the coal, a remarkable formation of globular nodules, (oblated, however, at the bottom, and on that account locally called "*bell moulds*,") is sometimes found in the heart of the rock, separated by a thick coating of oxide of iron. They are known to the colliers by fatal experience; for, while the miner is working in an inclined position, which is the case where the beds of coal are thin, the continued strokes of his pick-axe

* These dangerous fossils occur in the roof of the Bensham coal seam in the Wallsend collieries. The excellent Mr. Reay, of Carville, whose thigh was dreadfully fractured some years ago by the sudden descent of one of these "cauldrons," which at the same time killed the pitman at work near him, told the writer of this note that the mass was so large as to require six or eight men to lift it off the sufferer.

gradually loosens the bell mould, which eventually drops out of its socket, and kills or injures him without the least warning.* These lumps appear to resemble the nodules of bituminous shale encountered in the soft roofs of some Scotch collieries: they have a sort of unctuous smoothness, and are called by the miners *creeshy*, or greasy *bleas*. This oily smoothness, says Williams,† makes these irregular strata particularly troublesome and dangerous in a coal roof, as being thus full of joints and natural divisions, which run in all directions, the oil runs through all the joints, and occasions this sort of bleas to slip and fall out so soon as the coal is worked away from under it.

In Yorkshire, the vertical fissures already alluded to are called "bright heads," or "smooth heads," from the usually polished appearance of the coal at these sutures. This fissile structure of the rock, while it tends greatly to facilitate the labour of the pitman in riving down large masses of coal, is at the same time a frequent cause of accidents. When the workman has been for some time engaged in what is termed "holing under"—that is, undermining,—the wall of coal, apparently solid and firm, will sometimes suddenly give way, separating at the line of section formed by the "bright heads," and thus either bury the unfortunate excavator, or crush those who may happen to be in the way: casualties of this kind are of frequent occurrence.

More frequent and fatal are the calamities arising from sudden irruptions of water into the workings, in consequence of which the men are drowned before they can reach either the shaft, or any elevated le-

* Chilcott's Bristol Guide. † Mineral Kingdom, vol. i. p. 83.

vel.* A catastrophe of this class may occur, either in consequence of the miner unwarily tapping some concealed reservoir, or, as is more commonly the case, from the descent of a body of water through the intervening stratum, as when the Tunnel under the Thames was, on one occasion, suddenly inundated, and, short as was the excavation, and ready the means of ascent, several lives were lost by this bursting of the river through its bed. Accidents from this, as well as from the former source, depending as they do upon mechanical causes, may often be guarded against; though no degree of ingenuity or circumspection on the part of the overlookers, nor of precaution in the conduct of the colliers combined, can always prevent their occurrence. In 1833, the Lady and Isabella pits at Workington were suddenly inundated, by the bursting-in of an immense torrent from the old workings. There were thirty men underground at the time of the accident, who were rescued, with the exception of four, who fell victims. At Heaton Colliery, in the county of Durham, the

* A catastrophe which occurred in consequence of a sudden irruption of water into the pits at East Ardsley, near Wakefield, in June 1809, when ten individuals perished, has been made the subject of a Drama, by the Rev. J. Plumptre, B.D. Vicar of Great Gransden, Herts, entitled "Kendrew, or the Coal Mine." The author says in his preface, that "having visited a coal mine, at the Heaton Colliery, near Newcastle, in the summer of 1799, he adopted that as the foundation of his scenery: and endeavoured so to construct his piece, that, should it ever be performed, the audience might have an opportunity of having the interior of a coal mine, to which we are indebted for so much comfort, as it were presented and realized to them." It is not likely, however, that the drama was ever recited on the stage: the first act opens with a scene representing the top of the shaft, with the drawing machinery, &c., and a pitman singing a song, of which the following is the first verse:—

"Although the poor collier is dirty and grim,
The world yet derives great advantage from him:
Whilst you sit in your houses secure from the storm,
His labour contributes to make you so warm."

consequences of an irruption of water from the tapping of an old working, were, on one occasion, in 1815, much more deplorable, only eighteen or twenty men out of an hundred making their escape!

It will readily be conceived that the sound and appearance of an instantaneous rushing of a large body of water into the workings, must be awful indeed to those ingulphed therein—particularly when the lights are mostly or entirely extinguished! One of the earliest boyish impressions which the writer retains is connected with an event of this nature, which occurred in a Yorkshire colliery in the beginning of the year 1805. The bottom of a large dam suddenly gave way, and poured its contents into the mine beneath: one of the colliers, recording the deliverance of himself and fellows in verse, the mediocrity of which was relieved by the real impressiveness of the occurrence, thus sang:—

"It early in the morning was, our troubles did begin;
Near two o'clock, we understand, the waters rushed in:
Then many waded in the deep in such a wretched plight,
Their case, it dreary was indeed—they had no kind of light!
To hear the cries, and see the tears on this occasion shed,
The tragic scene, it was enough to cause the heart to bleed:
But the all-seeing eye of God, from whom we draw our breath,
Beheld, and by his Providence, preserved us all from death," &c.

In July, 1833, the Scotch newspapers contained a striking account of an accident of this nature; happily resembling the above also, in the fact of its being unattended by loss of life. On the 20th of June, in the forenoon, while Mr. Montgomery, banker, in Irvine, and another gentleman, were engaged in fishing on the river Garnock, nearly opposite to where they were standing, a slight eruption took place in the current of the river, which they at first supposed

to be occasioned by the leap of a salmon; but the gurgling motion which succeeded, led them to suppose that something serious had occurred, and that the river had broken into the coal mines which surrounded the place on which they stood. They immediately hastened to the nearest pit mouth, and stated their suspicions, which the pit headman at first was slow to believe, and it was only after Mr. Montgomery had strongly remonstrated with him, that he at length prepared to avert the danger. By this time, however, the men below had heard the rushing forward of the water, and were making the best of their way to the bottom of the shaft; but before they reached it, several were up to their necks in water, and in two minutes more, it was believed, every one of them would have been drowned. Immediately on the whole of the men being got out of the pits, Mr. Dodds, the active manager of the works, assembled all his men at the cavity in the bed of the river, over which they placed a coal-lighter, laden with such things as they thought calculated to stop the rush of the water, as straw, whins, clay, &c.; all their efforts, however, proved unavailing, for the water continued to pour into the mines without obstruction, producing comparatively very little agitation on the surface of the river until the following afternoon, when a tremendous large space broke down, which in a short time engulphed the whole body of the stream, leaving the bed of the river quite dry for more than a mile on each side of the aperture, where there had previously been a depth of fully six feet. At this time, the fishes in the channel were seen leaping about in every direction. On the flowing of the tide the depth of the water betwixt the chasm and the sea increased to

about nine feet; then the desolation was awful! The long sweep, and prodigious quantity of water rushing into the chasm at this time made the sight impressive beyond description. Three men, who were in a boat near the spot, had a very narrow escape from being sucked into the vortex, for no sooner had the men got out than the boat was drawn down with fearful rapidity. The great body of water continued to pour down the chasm, until the whole workings of the pits, which extend for many miles, were completely filled; after which the river gradually assumed its natural appearance, and the water attained its ordinary level. At this time, the pressure in the pits became so great, from the immense weight of water impelled into them, that the confined air, which had been forced back into the high workings, burst through the surface of the earth in a thousand places, and many acres of ground were to be seen all at once bubbling up like the boiling of a cauldron. In some places the current was so impetuous as to form cavities four or five feet in diameter, and produced a roaring noise, like the escape of steam from an overcharged boiler. Immense quantities of sand and water were thrown up like showers of rain during five hours, and in the course of a short time the whole of Bartonholme, Longford, Snodgrass, and Nethermains, were laid under water, by which calamity from five to six hundred persons, men, women, and children, were entirely deprived of employment. By this unfortunate occurrence, the extensive colliery works in question were injured to an extent which almost precludes the hope of their ever being restored to their former state.

The occurrence of fires, although commonly more

injurious to the mine than dangerous to the workmen, demands at least a passing notice. Fires sometimes occur spontaneously*, from the decomposition of iron pyrites in contact with moisture; more frequently, they are occasioned by explosions of inflammable gas, or other accidents†; and occasionally, it is painful to add, they are kindled by the hand of the incendiary‡. In either case, the waste of coal, and injury to the works, must often be very considerable. Many instances of fires from the first cause, are on record§; the combustion of large heaps of matter

* An interesting instance of spontaneous combustion was formerly seen—indeed Dr. Brewster says it exists at this moment, near the village of Maiden Bradley, near Bilston, in Staffordshire. The earth is here on fire, and this fire has continued for nearly sixty years, and has resisted every attempt that has been made to extinguish it. This fire, which has reduced many acres of land to a mere calx, arises from a burning stratum of coal about four feet thick, and eight or ten yards deep, to which the air has free access, in consequence of the main coal having been dug from beneath it. The surface of the ground is sometimes covered for many yards with such quantities of sulphur, that it can be easily gathered. The calx has been found to be an excellent material for the roads, and the workmen who collect it, often find large beds of alum of excellent quality.

† We believe there is no instance on record of any coal seam in England having ever been fired by lightning. In Fifeshire, however, as we are assured by Scotch gentlemen, the exposed basset-edges of the strata have been kindled through such agency.

‡ The colliery of Earl Fitzwilliam, at Rawmarsh, near Rotherham, was wilfully fired in 1833, as another of his Lordship's pits had been on a former occasion of some dissatisfaction among the workmen. The punishment awarded by law for "wilfully and maliciously setting on fire any mine, pit, or delph of coal, or cannel coal, is felony without benefit of clergy." 10 Geo. II. c. 32. And "setting fire to, demolishing, or otherwise damaging, any engine or any other thing belonging to coal mines, is felony and transportation for seven years." 9 Geo. III. c. 29.

§ In 1830, the Stirling Journal contained the following singular notice:—"It is now more than two years since the snow lying on a field on the farm of Shaw Park, belonging to the Earl of Mansfield, was observed to melt almost as soon as it fell, and then rise in a state of vapour. The phenomenon attracted the attention of the Managers of the Alloa and Devon Collieries, and was found to be the effect of the heat produced by a stratum of coal in a state of ignition, technically known by the name of the Nine Feet Seam, from which the Devon Ironworks are supplied with a large proportion of their fuel.

about the pit's mouth so originated, is very common; and there have been some striking instances of a similar occurrence, on board coal ships, both before leaving the river Tyne, and when at sea. Considerable devastation was caused on Newcastle Town Moor, by the accidental firing of the coal strata near the village of Benwell, about the middle of the seventeenth century; traces of this pseudo volcano, are still clearly visible in the red shale, cinders, and other charred matter with which the ground is strown, about the adjacent estate of Fenham.* The most remarkable instances, however, of devastation from these causes, are those near the towns of Wednesbury, in Staffordshire, and Dudley, in Worcestershire: here, there are vast masses of coal on fire, which have been burning for ages, owing, as is supposed, to the decomposition of pyrites.

Various plans were, at the same time, suggested to extinguish the flames, and after several failures it was determined to cut a mine round the seam to prevent their extension. Workmen were set to excavate this mine, which was opened at both sides of the seam, to build a wall as they proceeded, on the sides of the two tunnels next the fire. In this way it was intended to proceed, till the tunnels penetrated beyond the fire, when they were to be joined in the form of a horse-shoe, and thus cut off, by means of a strong wall, all connexion between the ignited part of the seam and the remainder of it. This plan has been persevered in for a year and a half, but has never been completed. The workmen have often brought two walls within a few fathoms of meeting, but owing to the fire bursting in upon them, they have been hitherto obliged to fall back again and take a wider circle. Six or seven shafts have been sunk to ventilate the tunnels, in which the heat is frequently so great as to raise the thermometer from 212 to 230 deg. Fahrenheit; it sometimes rises even higher. The lamps of the miners, which are hung upon the walls, have more than once fallen to pieces from extreme heat."

* In 1673, Mr. Durant, of Newcastle, transmitted an account of this subterranean conflagration to the celebrated Robert Boyle, who laid it before the Royal Society. It appears that at that time the fire had been burning about thirty years; it was occasioned by a candle negligently placed by a pitman while at work, and was at first of such small account, that it is said half-a-crown was denied to a man who, for that trifling sum, would have undertaken to extinguish it.

The most awful, the most fatal, and, it is lamentable to add, the most frequently occurring accidents, are those arising from the accumulation of inflammable gas, or mephitic vapour. The mere enumeration of the instances in which men have been scorched, stifled*, and suddenly hurried into eternity singly, or by scores, would occupy a large space. Instead, however, of attempting to give at length, such a catalogue of calamities, it may be sufficient to detail from the account of the Rev. J. Hodgson, already quoted in the description of Felling Colliery, the particulars of the explosion which took place there in 1812, and the melancholy circumstances attending the catastrophe. The general plan of the colliery has been already described, and the fact stated that, the mine, up to the moment of the accident, was considered by the workmen, a model of perfection in all its arrangements. In the forenoon of the 25th of May, 1812, the villages in the neighbourhood of this colliery were alarmed by a tremendous explosion. The subterraneous fire broke forth with two heavy discharges from the John Pit, followed by one from the William Pit. A slight trembling, as from an earthquake, was felt for about half a mile round the workings; and the noise of the explosion, though dull, was heard to three or four miles distance, and much

* An elegant writer (Dr. Walsh) has thus poetically described two of the less common harbingers of choke damp and fire damp, those ministers of death, whose approach is frequently as insidious as it is destructive. "At one time, an odour of the most fragrant kind is diffused through the mine, resembling the scent of the sweetest flowers; and while the miner is inhaling the balmy gale, he is suddenly struck down and expires in the midst of his fancied enjoyment: at another, it comes in the form of a globe of air enclosed in a filmy case; and while he is gazing on the light and beautiful object floating along, and is tempted to take it in his hand, it suddenly explodes, and destroys him and his companions in an instant."

resembled an unsteady fire of infantry. Immense quantities of dust and small coal accompanied these blasts, and rose high into the air in the form of an inverted cone. The heaviest part of the ejected matter, such as corves, pieces of wood, and small coal, fell near the pit; but the dust, borne away by a strong west wind, fell in a continued shower from the pit to the distance of a mile and a half. In the village of Heworth, it caused a darkness like that of early twilight, and covered the roads so thickly, that the footsteps of passengers were strongly imprinted in it. The heads of both the shaft-frames were blown off, their sides set on fire, and their pullies shattered in pieces—those of the John Pit gin, being on a crane not within the influence of the blast, were preserved. The coal dust, ejected from the William Pit into the drift or horizontal parts of the tube, was about three inches thick, and soon burnt to a light cinder. Pieces of burning coal, driven off the solid stratum of the mine, were also blown up this shaft.

As soon as the explosion was heard, the wives and children of the colliers ran to the working pit. Wildness and terror were pictured in every countenance. The crowd from all sides soon collected, to the number of several hundreds, some crying out for a husband, others for a parent, or a son; and all deeply affected with an admixture of horror, anxiety, and grief. The machine being rendered useless by the irruption, the rope of the gin was sent down the pit with all expedition. In the absence of horses, a number of men, whom the wish to be instrumental in rescuing their neighbours from their perilous situation, seemed to supply with strength proportionate to the urgency of the occasion, put their shoulders to the

shafts of the gin, and wrought it with astonishing expedition. By twelve o'clock, thirty-two persons, all that survived this dreadful calamity, were brought to daylight, and along with them the dead bodies of two boys—three other boys dying in a few hours. Only twenty-nine persons were, therefore, left to relate what they observed of the appearances and effects of this subterraneous thundering: one hundred and twenty-one were in the mine when it happened, and eighty-seven remained in the workings. Eight persons had come up at different intervals, a short time before the explosion. It is impossible to describe the shrieks, howlings, and wringing of hands which characterised the persons on the spot at this crisis: they who had their friends restored, hastened with them from the dismal scene, and seemed, as Mr. Hodgson remarks, for a while to suffer as much from excess of joy as they had lately done from grief.

The persons who remained in the mine, had all been employed in the workings to which the plane-board was the general avenue, and as none had escaped by that way, the most intense apprehension for their safety existed. At noon, nine courageous individuals descended the John Pit in expectation of meeting with some of them alive. As the fire damp would have ignited at candles, they lighted their way by steel mills, the machines already described, which give light by turning a plain thin cylinder of steel against a piece of flint. Knowing that a great number of the workmen would be at the crane when the explosion happened, they attempted to reach it by the plane-board: but their progress was intercepted at the second pillar by the prevalence of choke-damp —the sparks from the steel-mill falling into the

noxious fluid like drops of blood. Being, therefore, deprived of light, and nearly poisoned for want of atmospheric air, they retraced their steps to the shaft, and then attempted to pass up the narrow boards: in these, they were stopped at the sixth pillar by a thick smoke, which stood like a wall the whole height of the board. With difficulty, they found their way to the pit bottom, persuaded that the mine was on fire, and before they had all ascended another explosion, though much less severe than the first, took place. The men at the bottom, saved themselves by suddenly lying down on their faces—though they felt the heat and energy of the blast very seriously.

As these adventurous men were successively drawn to bank, all their reports as to the chance of any person remaining alive in the mine, were equally hopeless: notwithstanding, however, their statements, and the corroborating circumstance of the second explosion, persons were not wanting to infect the minds of the relatives of the sufferers with disbelief in the accounts of the persons who had explored the mine. It was suggested that want of courage, or bribery, might be the inducements to magnify the dangers, and represent the impossibility of reaching the bodies of the unfortunate men. By means of this species of wicked industry, the grief of the neighbourhood began to assume an irritable and gloomy aspect. The proposition to exclude the atmospheric air from the mine, in order to extinguish the fire, was therefore received with cries of "Murder," and with determinations of opposing the proceeding. Many of the widows continued about the mouth of the John Pit during the whole of the night, with the hope of hearing the voice of a husband or a son calling for

assistance. On the day after the accident, an immense crowd of colliers from various parts, assembled round the pits, and were profuse in reproaches on the persons concerned in the mine, for want of exertion to recover the men. Every one had some example to relate of successful attempts in exigencies of this kind,—all were large in their professions of readiness to give assistance; but none were found to enter the inflammable jaws of the mine, though the proprietors gave the strongest assurances to the crowd, that if any project could be framed for the recovery of the men, no expense should be spared in executing it; if any person could be found to enter the mine, every facility and help should be afforded him; but, as they were assured by the unanimous opinion of several of the most eminent Viewers in the neighbourhood, that the workings of the mine were in an unapproachable state, they would hold out no reward for the attempt: they would be accessary to no man's death by persuasion or bribe.

After another ineffectual attempt to proceed from the shaft towards the workings, the hope was abandoned, and it was resolved to exclude the atmospheric air, in order to extinguish the fire which the explosion had kindled in the mine, and of which the smoke ascending the William Pit, was a sure indication. This shaft was accordingly filled with clay about seven feet above the *ingate*, or entrance into the drift; and the John Pit mouth was covered over with loose planks. In two days afterwards, twenty fothers of additional clay were thrown into the William Pit, in order to insure its being air-tight: in the next place, a scaffold, at 25½ fathoms from the surface, was suspended on side ropes, each six inches in circum-

ference in the John Pit. Upon this a large quantity of straw, and afterwards twenty-six fothers of clay were thrown, to render the whole air tight. On the 1st of June, this suspended mass fell into the pit; and also another, subsequently constructed: at length a scaffolding of planks on stout beams of timber was laid across.

Preparatory to re-opening the mine, a brattice or thin partition of deals, was put down the William Pit, and intended, by promoting a temporary circulation, &c. to assist the workmen in raising the clay and other matters which had been previously thrown down. About this time many idle tales were circulated through the country concerning several of the men finding their way to the shafts, and being recovered. Their number was circumstantially told—how they subsisted on candles, oats, and beans—how they heard the persons, who visited the mine at the time of the accident, but were too feeble to speak sufficiently loud to make themselves heard. Some conjuror, too, it was said, had set his spells and his divinations to work, and penetrated the whole secrets of the mine. He had discovered one famishing group receiving drops of water from the roof of the mine—another eating their shoes and clothes, and other such pictures of misery. These inventions were carefully related to the families of the colliers, and answered the purpose of every day harrowing up their sorrows afresh. Indeed it seemed the chief employment of some to make a kind of insane sport of their own and their neighbour's calamity.

On the 19th of June, the water oozing out of the tubbing of the William Pit, had risen to the height of twenty-four feet upon the clay. On the

3d of July, this being all overcome, the brattice finished, and a great part of the clay drawn up, the sinkers began to bore a creep-hole out of the shaft into the north drift. On the next day, the stoppings in the tube drift of the John Pit were taken down, and the bore-hole finished, through which the air passed briskly into the mine, and ascended by the John Pit tube: and after a few days, the vapour issuing, which in the beginning took fire on the application of a candle, lost that property in consequence of the influx of atmospheric air.

The workmen having pierced into the drift, through the clay in the William Pit, and the morning of the 8th of July being appointed for entering the workings, the distress of the neighbourhood was again renewed at an early hour. A great concourse of people collected—some out of curiosity—to witness the commencement of an undertaking full of sadness and danger—some to stir up the revenge and aggravate the sorrows of the relatives of the sufferers, by calumnies and reproaches, published for the sole purposes of mischief; but the greater part came with broken hearts and streaming eyes, in expectation of seeing a father, a husband, or son, "brought up out of the horrible pit." As the weather was warm, and as it was desirable that as much air might pass down the pit as possible, constables were placed to keep off the crowd: two surgeons were also in attendance in case of accidents.

Nine persons descended the William Pit, and as a current of water had been thrown down during ten hours, they found it practicable to traverse the north drift towards the plane board, lighting their way by means of steel mills. The shifts of men employed

in this doleful and unwholesome search, were generally about eight in number: they were four hours in and eight hours out of the mine. The first body was found near the plane-board; and for a while the men stood over it in speechless horror, imagining that it was in such a state of decomposition that it would fall asunder in lifting into the coffin. At length they began to encourage one another "in the name of God," to begin: and after several hesitations and resolutions, and covering their hands with oakum to avoid any unpleasant sensation in touching the body, they laid it in a shell, which was drawn "to bank," on a bier constructed for the purpose. When the first shift of men came up, at ten o'clock, a message was sent for a number of coffins to be in readiness at the pit: these, being at the joiner's shop, piled up in a heap, to the number of ninety-two,—a most gloomy sight!—had to pass Low Felling. As soon as a cart load of them was seen, the howlings of the women, who had hitherto continued in their houses, but now began to assemble about their doors, came on the breeze in slow fitful gusts, which presaged a scene of much distress and confusion being soon exhibited near the pit; but happily, by representing to them the shocking appearance of the body that had been found, and the ill effects upon their bodies and minds, likely to ensue from suffering themselves to be hurried away by such violent convulsions of grief, they either returned to their houses, or continued in silence in the neighbourhood of the pit. Mr. Hodgson details with much minuteness the circumstances in which the bodies of the sufferers were respectively discovered—sometimes buried beneath the fall of the roof, but mostly lying exactly in

the position in which they appeared to have been thrown at the moment of the explosion. In one place, twenty-one bodies lay together in ghastly confusion: some like mummies, scorched as dry as if they had been baked. One wanted its head, another its arm. The scene was truly frightful. The power of fire was visible upon all; but its effects were extremely various; while some were almost torn to pieces, there were others who appeared as if they had sunk down overpowered with sleep. At the bottom of the plane-board, the body of a mangled horse and four shattered waggons were found: the latter were made of strong frames of oak, strengthened with hoops and bars of iron, yet the blast had driven both them and the horse with such violence down the inclined plane-board that it had twisted and shattered them, as if they had been shot from a mortar against a rock.

On one occasion during the progress of raising the bodies, and while the workmen were clearing out the water-sumph or well, which had been sank at the bottom of the John Pit to collect the water that drained through the tubbing, a gust of fire-damp burst from the workings, and ascended the shaft. This caused so great an alarm, that the cry "Send away a loop!" from the bottom, and "Ride away! Ride away!" from the banksmen, were heard together. Seven of the men clung to the rope, and arrived safe at bank; and two old men threw themselves flat on their faces, in expectation of an explosion; but after a second and similar eructation, the atmospheric current took its usual course. This phenomenon was afterwards ascertained to proceed from a large fall at that time taking place in the

stable board, and forcing back a foul admixture of the two damps and common air. The banksman's cry so alarmed the villages of High and Low Felling, that all the inhabitants, young and old, hastened to the pit.

From the 8th of July to the 19th of September, the heart-rending scene of mothers and widows examining the putrid bodies of their sons and husbands, for marks by which to identify them, was almost daily renewed; but very few of them were known by any personal mark—they were too much mangled and scorched to retain any of their features. Their clothes, tobacco boxes, shoes, and the like, were, therefore, the only indexes by which they could be recognised. Every family had made provision for the entertainment of their neighbours on the day the bodies of their friends were recovered; and it had been generally given out that they intended to take the bodies into their own houses. But Dr. Ramsay having given his opinion that such a proceeding, if carried into effect, might spread putrid fever through the neighbourhood, they, after seeing the first body, readily consented to have them interred immediately after they were found—the hearse, however, on its way to the burying ground, passed by the door of the deceased. One of the bodies was never found: of the ninety-one recovered, all except four, were interred in Heworth Chapel-yard, in a trench side by side, two coffins deep, with a partition of brick and lime between every four coffins: a neat obelisk, nine feet high, was afterwards erected over this immense grave: it records on four brass plates the names and ages of the sufferers.

On the 19th of September the ventilation of the

Colliery was effected completely, and the workmen resumed their labours; but in little more than a year —namely, on the 24th December, 1813, another explosion occurred in the same mine, and killed twenty-three persons, and twelve horses; twenty-one individuals escaped, thirteen of whom were severely burnt. This explosion was certainly every way much less severe than the former; but as it happened when the morning shift of men were relieving the night shift, it might have been much more destructive than in fact it was: for a group of the fresh men were waiting to go down; and those who had just descended met the fatal whirlwind of fire in their way to the southern boards, which lie under the village of High Felling. That part of the mine was intersected with several dykes and fissures, which not unfrequently discharged great quantities of inflammable air, through the apertures called blowers, already described, and which made the small coals on the floor dance round their orifices, like gravel in a strong spring. Whether this accident was attributable to the falling of some matter so as to prevent the regular ventilation of the wastes, or to some neglect of the standing orders at the rarifying furnace in the upcast pit, could not be satisfactorily discovered; but so powerful was the stream of fresh air in all the workings, that the persons employed were unanimous in declaring, that they never wrought in a pit so wholesome and pleasant.

While the present sheet is passing through the press, the immediate neighbourhood of the above-mentioned accidents is in a state of indescribable distraction, in consequence of the occurrence of a catastrophe similar in nature, but still more disastrous in

the amount of fatality connected with it; indeed the oldest inhabitants of the district do not remember any thing equal to it as regards loss of life. On the afternoon of June 18th, 1835, an explosion of inflammable gas took place in the works of what is called "the Church Pit," in the Wallsend Colliery, by which one hundred and one human beings—about three-fourths of them boys—were suddenly hurried into eternity! It is unnecessary to go into the details of this appalling calamity: it may, however, be remarked that the works, which had been regularly inspected in the morning by the "under viewers," were considered in every respect safe and secure; so that whether the accident is to be referred to some of the miners having incautiously removed the head of their safety lamps, or to some other cause, will probably ever remain a mystery; as four persons—all who were saved—can give no account of the affair. Several of the bodies were black, shrivelled, and burnt; one or two were mutilated; but the greater number, as commonly happens in these cases, having been suffocated by the stythe or after-damp, had the appearance of being in a tranquil sleep. It appeared, indeed, from evidence offered on the Coroner's inquest, that by far the greater part of the sufferers had deliberately left the spot where they were at work, on hearing the explosion, and would in all probability have been saved, had not the fire-blast blown down various matters, so as to obstruct ventilation and ascent by the main shaft; and thus the victims perished by unexpected suffocation when fleeing for their lives. In 1821 there was an explosion in the same colliery, by which fifty-two lives were lost.

CHAPTER XIV.

THE SAFETY LAMP.

Circumstances which led to the formation of a Society for Preventing Accidents in Collieries—Application to Sir Humphrey Davy—Chemical Composition of the inflammable Gas of the Mines—Will not explode in small Tubes, nor from contact with red-hot Iron or Charcoal—First Safe Lantern—Wire-Gauze Cage—Description of the Common Safety Lamp—Testimonials of respect to Sir H. Davy—Opinions of Mr. Buddle and Mr. Fenwick in favour of the "Davy"—Petition of the Staffordshire Colliers—Circumstances under which Explosions have taken place in connexion with the Davy Lamp.

IF the appalling circumstances detailed in the preceding Chapter, comprising, as they do, but a very small part of the catalogue of calamities of that class, are calculated to make the least sensitive individual shudder with horror, by how much more must the public, and the pitmen especially, have been laid under obligation by those persons who have devised the means of lessening the number of such occurrences—or rather, invented a method of preventing them altogether. It was impossible, says Dr.

Paris,* after alluding to the first catastrophe at Felling Colliery, that an event of such awful magnitude should not have deeply affected every humane person resident in the district. Nothing, in short, could exceed the anxiety which was manifested on the occasion; but most unfortunately there existed an invincible prejudice against every proposition that could be offered, from a general impression of the utter hopelessness of any attempt to discover a remedy. A few philosophic individuals, however, did form themselves into an association for the laudable purpose of inviting the attention of scientific men to the subject, and of obtaining from them any suggestions which might lead to a more secure method of lighting the mines.

To the Rev. Doctor Gray, the late Bishop of Bristol, and who, at the period of the explosions at Felling, was Rector of Bishop-Wearmouth, Dr. Paris acknowledges himself indebted for the several highly interesting communications, by means of which he has "been enabled to present to the scientific world a complete history of those proceedings which have so happily led to a discovery, of which it is not too much to say that it is, at once, the pride of science, the triumph of humanity, and the glory of the age in which we live." It was at a time when all relief was deemed hopeless, that Mr. Wilkinson, a barrister in London, and a gentleman distinguished for the humanity of his disposition, suggested the

* "Life of Sir Humphrey Davy, by J. A. Paris, M.D. &c." From this source, as considered the most circumstantial and authentic, the present Chapter, on the subject of the Safety Lamp, is chiefly drawn. The work is altogether one of delightful interest. There have been several claimants of, and endless discussions upon, the invention of the Safety Lamp, explicit allusion to which will be found in the work here mentioned.

expediency of establishing a Society for the purpose of enquiring whether any, and what, methods of security could be adopted for the prevention of those accidents at that time so frequently occurring in the collieries of Northumberland and Durham. In consequence of this benevolent suggestion, a Society was established at Bishop-Wearmouth, on the 1st of October, 1813. A few days before the first meeting, twenty-seven persons had been killed in a colliery in which Sir Ralph Milbanke had an interest; he was, therefore, called upon at the first meeting to state the particulars of the accident. At that time, as Dr. Gray states, there was such little expectation that any means could be devised to prevent the occurrence of these explosions, that the object of the gentlemen who convened the meeting, however humane in principle, was considered by most of the persons present as chimerical and visionary. The Society, however, amidst many difficulties and considerable discouragement, and a perpetual harass by the offer of impracticable schemes from every quarter, nevertheless persevered in their meetings, and succeeded in establishing a communication and correspondence with other Societies in different parts of the kingdom.

It was in consequence of a private communication from Dr. Gray to his friend Sir Humphrey Davy, that the latter was first led to apply his profound chemical knowledge to an investigation of the nature of the inflammable gas of the coal mines, and also to a discovery of the best means for preventing the occurrence of accidents from this "fire damp," as it was called. In August 1815, Davy visited Newcastle-upon-Tyne, where he had an interview with

Mr. Buddle, one of the most intelligent coal viewers in the north, and who supplied the philosopher, on his return to London, with various specimens of natural gases collected in the colliery workings, for experiment. Sir Humphrey not only exercised his wonted scientific acumen, in examining the gases, but entered with all his heart into the subject; declaring, in one of his letters, that he "never received so much pleasure from the result of any of his chemical labours; for I trust," adds he, "that the cause of humanity will gain something by it."

"The fire-damp," says he, in a confidential communication, dated October 30, "I find, by chemical analysis, to be (as it has been always supposed) a hydro-carbonate.* It is a chemical combination of hydrogen gas and carbon, in the proportion of four by weight of hydrogen gas, and $11\frac{1}{2}$ of charcoal. I find it will not explode, if mixed with less than six times, or more than fourteen times its volume of at-

* The generation, latency, and evolution of this dreadful agent have given rise to much curious enquiry, though hitherto with only very partial success. Mr. Hutton, in a paper containing "Observations on Coal," read before the Geological Society in January 1833, and tending to confirm the importance of those microscopical investigations into the organic structure of this and other fossils, so beautifully carried out by Mr. Witham, ingeniously shews the probability of the gas existing within the coal in so compressed a state as to be liquid. Several circumstances induced Mr. Hutton, while engaged in his microscopic enquiries, to search for a structure in coal capable of containing gas; and he accordingly discovered a system of cells, different from any before noticed, and apparently adapted for that purpose. These supposed gas-cells are found empty, are generally of a circular form, occur in groups, which communicate with each other, and each cavity has in its centre a small pellet of carbonaceous matter. The author establishes a clear distinction between these cells and others which he describes as filled with bituminous matter; for the anthracite of South Wales contains the former, but is quite free from the latter. He also states, on the authority of Mr. F. Foster, that the anthracite of South Wales affords a free disengagement of inflammable gas, when first exposed to the air.—*Phil. Mag. Ap.* 1833. *p.* 303.

mospheric air. Air, when rendered impure by the combustion of a candle, but in which the candle will still burn, will not explode the gas from the mines; and when a lamp or candle is made to burn in a close vessel, having apertures only above and below, an *explosive mixture* of gas admitted *merely enlarges* the light, and then gradually extinguishes it without explosion. Again,—the gas mixed in any proportion with common air, I have discovered, *will not explode* in a *small tube*, the diameter of which is less than the ⅛th of an inch, or even a larger tube, if there is a mechanical force urging the gas through the tube. Explosive mixtures of this gas with air require much stronger heat for their explosion than mixtures of common inflammable gas. Red-hot charcoal, made so as not to flame, if blown up by a mixture of the mine gas and common air, does not explode it, but gives light in it: and iron, to cause the explosion of mixtures of this gas with air, must be made *white*-hot. The discovery of these curious and unexpected properties of the gas, leads to several practical methods of lighting the mines without any danger of explosion." Sir Humphrey then describes four lamps variously constructed, but respectively depending in the main upon the following principles: "First, a certain mixture of azote and carbonic acid prevents the explosion of the fire-damp, and this mixture is necessarily formed in the safe lantern;—secondly, the fire-damp will not explode in tubes or feeders of a certain small diameter. The ingress into, and egress of air from my lantern, is through such tubes or feeders; and, therefore, when an explosion is *artificially* made in the safe lantern, it does not communicate to the external air."

On the ninth of November, the views he entertained relative to the composition of fire-damp, and the methods proposed for encountering it with impunity, were laid before the Royal Society, in a paper entitled "On the Fire-damp of Coal Mines, and on methods of lighting the mine, so as to prevent its explosion." Dr. Paris details in a very lucid manner the progress of the enquiry, so far as regards the mechanical intervention of small tubes, fine circular orifices, or lastly wire-gauze between the lighted candle or lamp, and the explosive atmosphere of the mine, and in the scientific application of which the safety lamp directly resulted. From the issues of these researches it became at once evident, that to light mines invested with fire-damp, with perfect security, it was only necessary to use a well closed lantern, supplied with air from tubes of small diameter, through which explosions cannot pass, and with a chimney, on a similar principle, at the upper part, to carry off the foul air. A common lantern, to be adapted to the purpose, merely required to be made air-tight in the door and sides, and to be furnished with the chimney, and the system of safety apertures below and above the flame of the lamp. Such, in fact, was Davy's first safety lamp; and having afterwards varied the arrangement of the tubes in different ways, he, at length, exchanged them for canals, which consisted of close concentric hollow metallic cylinders of different diameters, so placed together as to form circular canals of the diameter of from one twenty-fifth to one fortieth of an inch; and of an inch and seven-tenths in length; by which air is admitted in much larger quantities than by the small tubes, and they are, moreover, much superior to the latter

in practical application. He also found that longitudinal air canals of metal might be employed with the same security as the circular canals; and that a few pieces of tin plate, soldered together, with wires to regulate the diameter of the canal, answered the purpose of the feeder or safe chimney, as well as drawn cylinders of brass.

On New Year's Day, 1816, Sir Humphrey Davy, writing to Dr. Gray, says, "I have made very simple and economical lanterns, and candle guards, which are not only *absolutely safe*, but which give light by means of the fire-damp, and which, while they disarm this destructive agent, make it useful to the miner." His original lamp with tubes or canals, as already described, was perfectly safe in the most explosive atmosphere, but its light was necessarily extinguished by it; whereas in the wire-gauze cage, ultimately adopted, and now in universal use, the fire-damp itself continues to burn, and thus to afford to the miner a useful light, while he is secured from or forewarned of the effects of explosion. All that is required for his guidance and protection in the darkness of the mine, is that the candles or lamps in use, be surrounded by small wire cages; these at once supply air to the flame, and light to the miner; being at the same time, perfectly safe. In Paris's work before mentioned, may be seen a sketch of the wire gauze instrument, in its first and simplest form. The original lamp is preserved in the laboratory of the Royal Institution. Davy found that iron gauze composed of wires from one fortieth to one sixtieth of an inch in diameter, and containing twenty-eight wires, or seven hundred and eighty-four apertures to the inch, was safe under all circumstances in atmospheres

of this kind; and he consequently employed that material in guarding lamps for the coal mines, where, in January, 1816, they were immediately adopted. The annexed cut, (*fig.* 36.) represents the lamp which is in present use. A is a cylinder of wire-gauze, with a double top, securely and carefully fastened, by doubling over, to the brass rim B, which screws on the lamp vessel C. The whole is protected and strengthened by strong iron-wire supports, rivetted into a piece at D. The lantern is carried or suspended by the ring attached to the flap E, which admits of being turned aside on its hinge, as shewn in the cut, in order that the gauze cap F, which is slipped on to guard against the chance of the top being burnt through, may be easily taken off and examined by the workmen every night. In some collieries this cover is kept locked during the period of using the lamp, to avoid any risk from those dangerous temptations to remove it which have occasionally led to explosions. G the tube where oil is supplied. It may be mentioned too, that in order to obviate the risque formerly incurred by the temptation to unscrew the cage off in order to trim the wick of the lamp, this end is provided for by means of a wire trimmer, which passes through the part containing the oil, and operates in the slit of the burner*.

Fig. 36.

* One strong objection formerly existing in the minds of the colliers against the use of the safety lamp, was its feeble illuminating power as compared with naked lamps or candles. Schemes have been proposed to remedy this defect, but with little success; among other means, reflectors have been affixed. This contrivance may be useful, in certain cases, but it does not possess sufficient advantages to recommend it to general adaptation.

It would hardly comport with the design—certainly not with the limits of the present work, to go into any examination of the evidence adduced in favour of various claimants to the invention of lamps or lanterns apparently analagous to or widely different from that of Davy: Dr. Paris has ably set forth and zealously defended the pre-eminent claims of his friend. It is due, however, to Mr. G. Stephenson, to record that a purse of one hundred guineas was presented to him by a number of gentlemen connected with the Coal Trade of Newcastle, in acknowledgment of the ingenuity displayed by him in the construction of a safety lamp.

In March, 1816, the thanks of a general meeting of proprietors of coal mines, held in Newcastle, were presented to Sir H. Davy. This public compliment was immediately followed by a project for presenting to the individual who had done such service to humanity, some more solid testimonial of respect on the part of the public and the coal owners. Meanwhile, the security-principle of the lamp was put to the most satisfactory test. Mr. Buddle stated that twelve dozens of them were used in Wallsend colliery, and that not an inch of human skin had been lost by fire, since their introduction.

On the 13th of September, 1817, Sir Humphrey Davy being expected to pass through Newcastle on his return from Scotland, preparations were made for and notice given of a dinner, which it was proposed should take place on the 25th instant, for the purpose of presenting to the illustrious philosopher an elegant service of plate which had been prepared for his acceptance. Upon this gratifying occasion, a very large party assembled at the Queen's Head,

consisting of a numerous and respectable body of coal owners, and such other gentlemen as had interested themselves during the progress of the investigation, or taken an active part in promoting the introduction of the lamp into the mines.

After the dinner had concluded, and certain toasts of form had been drank, Mr. Lambton, (now Lord Durham,) who filled the chair on that occasion, rose, and on presenting the service of plate to the illustrious guest, addressed him in a tone of great animation and feeling, in nearly the following terms :—

"SIR HUMPHREY,—It now becomes my duty to fulfil the object of the meeting, in presenting to you this service of plate, from the Coal-owners of the Tyne and Wear, as a testimony of their gratitude for the services you have rendered to them and to humanity. Your brilliant genius, which has been so long employed in an unparalleled manner, in extending the boundaries of chemical knowledge, never accomplished a higher object, nor obtained a nobler triumph. You had to contend with an element of destruction which seemed uncontrollable by human power; which not only rendered the property of the Coal-owner insecure, but kept him in perpetual alarm for the safety of the intrepid miner in his service, and often exhibited to him the most appalling scenes of death and heart sickening misery. You have increased the value of an important branch of productive industry; and, what is of infinitely greater importance, you have contributed to the preservation of the lives and persons of multitudes of your fellow-creatures. It is now nearly two years that your safety lamp has been used by hundreds of miners in the most dangerous recesses of the earth, and under

the most trying circumstances. Not a single failure has occurred—its absolute security is demonstrated. I have, indeed, deeply to lament more than one catastrophe, produced by fool-hardiness and ignorance, in neglecting to use the safeguard you have supplied; but these dreadful accidents even, if possible, exalt its importance. If your fame had needed any thing to make it immortal, this discovery alone would have carried it down to future ages, and connected it with benefits and blessings. Receive, Sir Humphrey, this permanent memorial of our profound respect and high admiration—a testimony, we trust, equally honourable to you and to us. Long may you live to use it—long may you live to pursue your splendid career of scientific discovery, and to give new claims to the gratitude and praise of the world!"*

Sir Humphrey having received the plate, replied as follows:—"GENTLEMEN,—I feel it impossible to reply, in an appropriate manner, to the very eloquent and flattering address of your distinguished Chairman. Eloquence, or even accuracy of language, is incompatible with strong feeling; and on an occasion like the present, you will give me credit for no small degree of emotion. I have been informed that my labours have been useful to an important branch of human industry connected with our arts, our manufactures, commerce and national wealth. To learn this from such practical authority is the highest gratification to a person whose ardent desire has always been to apply science to purposes of utility.

* In the year 1825, Sir Humphrey had the honour to receive from the Emperor Alexander of Russia, and, in compliment of this invention, a superb silver gilt vase, standing on a circular tray enriched with medallions. On the cover was a figure, of about sixteen or eighteen inches in height, representing the God of Fire, weeping over his extinguished torch.—*Paris.*

It has been also stated, that the invention which you are this day so highly honouring, has been subservient to the preservation of the lives and persons of a most useful and laborious class of men: this, coming from your own knowledge, founded upon such ample experience, affords me a pleasure still more exalted—for the highest ambition of my life has been to deserve the name of a friend to humanity. To crown all, you have, as it were, embodied these sentiments in a permanent and magnificent memorial of your good opinion. I can make only imperfect and inadequate efforts to thank you. Under all circumstances of my future life, the recollection of this day will warm my heart; and this noble expression of your kindness will awaken my gratitude to the latest moment of my existence." Sir Humphrey having sat down, and the cheering of the company subsided, the Chairman proposed the health of the illustrious chemist in three times three. To this Sir Humphrey returned thanks in an eloquent speech, including an eulogy on the benefits of scientific invention: adducing among other illustrations, the fact that science alone has made pit coal such an important instrument in the hands of the chemist and mechanic; it has made the elements of fire and water perform operations which formerly demanded human labour, and it has converted the productions of the earth into a thousand new forms of use and beauty. After drinking to the health and happiness of the company, the worthy Baronet proposed as a sentiment, "Prosperity to the Coal Trade." The healths of the Duke of Northumberland, the Bishop of Durham, and the Reverend Dr. Grey, were drank in succession, after which Sir Humphrey, accompanied

by the Chairman, retired amidst the enthusiastic plaudits of the meeting.*

In August, 1831, pending the publication of the Life of Davy, Dr. Paris wrote to Newcastle to obtain the latest intelligence relative to the use and advantages of the safety lamp. To one of these letters of enquiry, addressed through Sir Cuthbert Sharp, Mr. Buddle replies, "If the Davy lamp was exclusively used, and due care taken in its management, it is certain that few accidents would occur in our coal mines; but the exclusive use of the '*Davy*' is not compatible with the working of many of our mines, in consequence of their not being workable without the aid of gunpowder. In such mines, where every collier must necessarily fire, on the average two *shots* a-day, we are exposed to the risk of explosion from the ignition of the gunpowder, even if no naked lights were used in carrying on the ordinary operations of the mine. This was the case in Jarrow Colliery, at the time the late accident happened. As the use of gunpowder was indispensable, naked lights were generally used, and the accident was occasioned by a '*bag*' of inflammable air forcing out a large block of coal, in the face of a drift, from a fissure in which it had been pent up perhaps from the Creation, and firing at the first naked light with which it came in contact, after having been diluted down to the combustible point by a due admixture of atmospheric air. As to the number of old collieries and old workings which have been renovated, and as to the quantity of coal which has been, and will be saved to the public

* Davy was also highly gratified and affected, while in the North, by a written address which he received from the working colliers, thanking him on behalf of themselves and their families, for the preservation of their lives.

by the invention of the '*Davy*,' it is scarcely possible to give an account, or to form an estimate. In this part of the country," continues Mr. Buddle, "Walker's Colliery, after having been completely worked out, according to the former system, with candles and steel-mills, and after having been abandoned in 1811, was re-opened in 1818 by the aid of the '*Davy*,' and has been worked on an extensive scale ever since, and may continue to be worked for an almost indefinite period.* Great part of the formerly relinquished workings of Wallsend, Willington, Percy-Main, Hebburn, Jarrow, Elswick, Benwell, &c. &c. as well as several collieries on the Wear, have been recovered, and are continued in work by the intervention of the '*Davy*.'"

The following is a communication to the same effect from Mr. Fenwick, a gentleman of much practical ability: it affords, as Dr. Paris justly remarks, additional evidence of the utility of the lamp:—"Sir Humphrey Davy's safety-lamp has afforded much security in the general working of mines, particularly by enabling the Coal-owner to work, in several situations, the pillars of coal formerly left therein, which, under the system of working by candles, or open flame, was deemed hazardous and impracticable; and, in consequence, one-sixth part more of coal, may be estimated as obtainable from those mines which are subject to hydrogen gas. Also in the working

* The opportune improvement and application of the steam engine for drawing the water out of mines already becoming too deep to be drained by the ordinary hydraulic machines, has already been adverted to; and it is a fact no less worthy of notice, that the invention of the safety lamp took place at a time when the steam engine was perfect in its application to collieries, whilst the difficulties and dangers attendant upon getting the deep coal, appeared in many places to indicate the limit of justifiable progress in connection with any mode of ventilation then known.

of the pillars of coal (commonly called the second working), great advantages and securities, as well as a saving of expences, have resulted from the use of this lamp, not only to the lessees of collieries, inasmuch as more coal is obtained from a given space than before, (particularly in collieries subject to fire-damp,) but also to the lessor of such mines, by their being more productive, and of course, more durable than heretofore. Another advantage results from the use of this safety lamp, and in the working of the pillars in particular. It is found now, through experience, that the changeable state of the atmosphere, which our barometers daily indicate, has a most powerful effect on the noxious air in mines; as, from a sudden change in the atmosphere, indicated by the rapid fall of the mercury in the barometrical tube, a rapid discharge of noxious gas into the workings and excavations of the mine is the consequence, caused by the want of atmospheric equilibrium: in which case the mine becomes suddenly surcharged with hydrogen, and if worked by the light of *open flame*, an explosion may take place before the possibility of such a circumstance can even be suspected; but if worked by the safety-lamp, it is only shewn by the gas in the lamp becoming a pillar of harmless fire. This circumstance frequently takes place when any atmospheric change causes the mercury in the barometer to sink to twenty-eight inches and a half, or thereabouts."

In March, 1834, a petition was presented to the House of Commons by Mr. Littleton, M.P. for Staffordshire, on behalf of the "Coal Masters and Miners of the Staffordshire Collieries, and of the Collieries in the neighbourhood of Dudley," praying "that

some legislative measure may be provided, appointing a Scientific Board to examine all lamps intended to be offered for sale to the public as safety lamps to be used in collieries, and to direct the stamping all such as they shall approve, and to prohibit the sale of any as safety lamps, which shall not be so approved; and also to examine a safeguard to enable workmen, when necessary, to enter places infected with mephitic gases."* The petitioners, to shew that their apprehensions of the jeopardy in which they stand are not groundless, submit to Parliament the consideration that, within the preceding eight months, more than one hundred industrious men have been deprived of life, or greatly injured in their persons, by explosions of inflammable air in coal pits, viz.:—On the 9th of May preceding, forty-seven persons were destroyed, any many severely wounded, by an explosion at Springwell Colliery, near Newcastle; on the 1st of September, in Oldbury, near Dudley, thirteen were greatly injured, of whom three are since dead; and, near the end of the same month, at Mr. Kirwen's Colliery near Workington, fourteen men were killed, and several severely hurt; besides several minor accidents attended with death, within that short period. Throughout this prolix document, the name of Davy does not once occur; and, what is still more remarkable, it is no where asserted in this petition, or in any of the accounts of the catastrophies published, that the safety-lamp devised by that individual was, although constantly used, the cause of a single ex-

* A Committee of the House of Commons, appointed to enquire into the causes and prevention of accidents in coal mines, had been sitting some time, when the accident at Wallsend, mentioned in the preceding Chapter, occurred to quicken attention to the subject. Numerous witnesses have been examined, but as yet, (July 29, 1835), no report has been printed.

CHAPTER XV.

THE COLLIERS.

Pitmen possess distinct Characteristics—Working in the Mines an ancient penal employment—Intelligence of Colliers, and Individuals who have risen into notice from among them—Morals, Recreations, and Tastes—Wages—Dwellings and Habits of the Pitmen about Newcastle—Denominations of Overseers and Workmen—Undertakers of Coal Pits in Staffordshire—The Colliers—Instance of their mode of exciting Charity—Misunderstandings between the Tyne Pitmen and their Masters—Combinations—A "Stick" or Strike—Injurious consequences of the Disputes—Murder of a Magistrate—Gibbet on Jarrow Slake.

HAVING described the dangers which beset the colliers, and the accidents to which they are more particularly liable while pursuing their underground labours, as well as the contrivances that have been devised for mitigating the most fearful and frequent of those accidents, it may not be here out of place, to introduce a few succinct notices of the more prominent characteristics of a class of men to whose labours we are daily indebted in such a variety of ways.

The colliers, or pitmen, as they are more commonly called in the north, are, or, perhaps, to speak more accurately—they *were*, a class hardly less distinct in character and habits from the rest of the community, than sailors themselves :* it is true, the element upon which the seaman lives, the perils to which he is inured, and the peculiar discipline of the naval service, have nothing in common with the depth, the darkness, nor the dangerous operations of the mine. But still, the latter cimmerian region usually differs so much from the scene of man's ordinary daylight avocations above ground, as often to impress very distinct traits upon those who are wholly brought up therein. These remarks, however, as above intimated, will apply with much greater force to the circumstances of past times,—the present race of colliers having, in common with even sailors themselves, been exposed to the assimilating effects of the "march of intellect," and happily, too, in many instances, to the still more important influence of moral improvement.

Among the ancients, and in some despotic states at the present time, subterranean mineral operations, have been chiefly carried on by criminals or captives; and in hot climates amidst certain descriptions of strata, the occupation is noisome and destructive to the last degree. Moralists, indeed, have regarded

* This similarity, the writer finds has been noticed by the Rev. L. Booker, Vicar of Dudley, who in September, 1816, a period of great depression in the Staffordshire collieries, published in the "Times" newspaper, a moral song, entitled "The Collier's Petition," intended to aid those who were compelled to beg about the country. After alluding to the various imposters who duped the charitably disposed in the guise of pitmen, the Rev. writer says, "The native collier of the district is a different character—generous and honest hearted, he possesses many features of mind resembling those of the British sailor."—*Times, Sept.* 4, 1816.

the danger and the difficulty of extracting the various matters laid up in the bowels of the earth, as among the most striking proofs that man is in a state of penal subjection to the consequences of the first offence. "Is it conceivable," enquires the Rev. T. Gisborne,* "that men, innocent, happy in the full enjoyment of the paternal favour of God,—men dwelling in an actual or virtual paradise, should be doomed by their heavenly Father to seek the mineral productions, which we are supposing them to need in such a situation, and to find that in such a state? Is it conceivable that they should be appointed to delve in subterranean darkness amidst water and mire, amidst the crash of falling caverns, the suffocations of mephitic air, and the explosions of fire-damps? Is it conceivable that, like the criminals of ancient Rome, or the enslaved Indians of Spanish America, they should be thus 'damnati ad metalla'—*condemned to the mines?*† Assuredly we may conclude," adds our author, "that, if to innocent and favoured man minerals were of importance, they would be provided for him by Divine goodness in stations easy of detection and of access, and would be endued with the qualities necessary for his purpose."

The pitmen in this country, may be regarded as a hardy—if not an athletic race: indeed the late Dr. Brownrigg, of Whitehaven, has pronounced "the various occupations of the coal miner to be at once a profitable and even a healthy employment."

* Testimony of Natural Theology, p. 17.

† It is said that in ancient times, the Scotch colliers had so little relish for their employment, and were, at the same time, in such a servile condition, that they were chained to the pits. In such case, they would literally be the "swarty slaves," of whom Jago speaks, in his poem of "Edgehill:" the appellation, however, does not apply to any class of pitmen, at this day, in Great Britain.

The Cornish miners have often been referred to as being a remarkably observant and intelligent race of men: combining, as they commonly do, each in his own person, the labourer, the adventurer, and the merchant, they have acquired a degree of shrewdness and industry that could not fail to be noted, especially by strangers with whom they came into contact. The colliers, on the other hand, whether less knowing or not, have been in this respect at least, less known: they have almost uniformly been the servants of capitalists between whom and the actual labourers there have existed several gradations of rank—so to speak—the duties of the uppermost of which, however, bear very lightly, if at all on the real independence of the lowest—the latter indeed frequently rising meritoriously from the bottom to the top of the scale. Many honourable instances of this might be mentioned. It is no proof of the general intelligence of any body of operatives, that men of talent have occasionally risen from among them to distinguished stations in society; but it is natural to associate the ultimate fame or notoriety of an individual with his original calling, and this, without the least disparagement or disrespect. It is on this principle that one feels a certain description of interest in knowing that the late celebrated Doctor Hutton was originally a hewer employed in Old Long Benton Colliery; that Mr. Stephenson, the intelligent engineer of the Liverpool and Manchester Railway, was originally a coal miner; that the late Rev. W. Huntingdon, an eccentric but talented preacher in the Metropolis, was a coal-heaver; and even that the late "king of the conjurers" as the ingenious Ingelby was called, was a pitman, who first practised

slight of hand among his companions on the banks of the Tyne. Thomas Bewick too, "the celebrated xylographer and illustrator of nature," may be mentioned as another instance. His father was a collier in the neighbourhood of Hexham; and Thomas with his brothers—one of whom died, after giving promise of high excellency in the beautiful art of wood engraving—"was early immured in that subterranean, laborious, and loathsome employment. I have heard him say," remarks his friend Mr. Dovaston,* "that the remotest recollection of his powerful and tenacious memory was that of lying for hours on his side between dismal strata of coal, by a glimmering and dirty candle, plying the pick with his little hands—those hands afterwards destined to elevate the arts, illustrate nature, and promulgate her truths, to the delight and instruction of the moral and intellectual world."

At a period when the nation generally was in a state of apparent apathy as regarded the doctrines and duties of our holy religion, it was not to be expected that

"The few—faithful among the faithless found,"

would be colliers: indeed it should not have been surprising to any one that among men so circumstanced, morality, or at all events piety, was at the lowest ebb. Such was the fact: and those persons only who are acquainted with the labours of the late Rev. John Wesley and his zealous coadjutors, in preaching at the risk of their lives among the colliers of Kingswood and elsewhere, can have any just notion of the state of ignorance and brutality which prevailed. Their sports and pastimes were mostly of

* Mag. Nat. Hist. i., 313.

that barbarous description of which happily few traces at present remain, such as bull-baiting, cock-fighting, boxing, &c. On the other hand, a taste for music largely prevailed, there being found among the pitmen not only those who could play upon the more common instruments, but in some of the hamlets entire bands were made up. It may be added that some of these grimy men are considerable readers of works not always found in the hands of workmen, such as metaphysical treatises, &c. On religious subjects, many of them are exceedingly well informed; and instances of remarkable piety have repeatedly been furnished by the pitmen.* The wages of the collier differ, of course, according to circumstances; being in general, however, paid according to the number of chaldrons sent to bank. When hiring was common, the master stipulated that the hewer should be allowed to earn 14s. or 15s. per week on the average, whether the works went on or not: the men could, however, sometimes earn 6s. or 7s. a day, though this was rarely the case for any length of time, except under peculiar circumstances. The wages are paid once a fortnight on the Friday, the intervals being designated as *Baff*, and *Pay* week. In general, the perquisite of having coals found for

* There is, indeed, no class of persons, sailors themselves not excepted, who have greater reason to live in constant readiness to encounter sudden death, than the colliers who work in some of our deep and impure mines. The following is a striking illustration of the prevalence of pious sentiments under circumstances of excruciating trial:—In one of the Newcastle collieries, thirty-five men and forty-one boys died by suffocation, or were starved to death; one of the boys was found dead with a Bible by his side, and a tin box such as colliers use; within the lid he had contrived to engrave with the point of a nail this last message to his parent and brother: "Fret not, my dear Mother, for we are singing the praises of God while we have time. Mother, follow God, more than ever I did. Joseph, think of God, and be kind to poor Mother."

their own use, is included in agreements with the master. Commonly the quantity is so many loads, or tons in the year; sometimes as much as an individual can carry away at certain intervals.*

The pitmen in the north of England, reside much less commonly in the towns or villages than in clusters of small houses adjacent to the respective collieries, and forming together little colonies, often more remarkable for the amount of the population, than the neatness or cleanness of their domestic arrangements: the latter circumstance is frequently attributable less to the absence of good housewifery than to other obvious causes. On the other hand, it is but justice to remark, that many of the houses of the colliers are patterns of cleanliness. Most of the old pitmen had a taste for expensive furniture—a taste still indulged by many; and it would be impossible for a stranger to pass in front of the lowly dwellings, three or four hundred in number, adjacent to Jarrow colliery, for example, without being struck by the succession of carved mahogany bed-posts, and tall chests of drawers, as well as chairs of the same costly material, which are presented at almost every open door: it is affirmed, indeed, that some of these mean looking habitations do not contain a single article in wood of any other kind. These congregated dwellings are the property of the owners, or lessees of the coal, and as the occupants pay no

* The manner in which the wives of the Lancashire colliers, are sometimes seen struggling with large coals, shews at once that they are paid on the same principle with Donald Ross, the public executioner of Inverness, who, in 1812, was allowed, among other perquisites, to receive for fees in fuel, thirty-five peats weekly, from the tacksman of the petty customs; a bushel of coals out of every cargo of English coals imported into the town, and a piece of coal *as large as he could carry* out of every cargo of Scotch coals.

rent—or at least, not in a direct manner, three-pence a week being usually set off in the reckoning for house and coals—they are considered to be removable at pleasure: i. e. when they chose to go and work for another master. Removals of this sort, however, were formerly less frequent on the whole, than might be supposed, the pitmen hiring and re-hiring themselves to their employers for a given time, and receiving, at the same time, a bounty often amounting to several pounds, and which money, in too many instances, was presently squandered away in gambling and intemperance. In their dress, the pitmen, singularly enough, often affect to be gaudy, or rather they did so formerly, being fond of clothes of flaring colours. Their holiday waistcoats, called by them *posey jackets*, were frequently of very curious patterns, displaying flowers of various dyes: their stockings mostly of blue, purple, pink, or mixed colours. A great part of them used to have their hair very long, which on work-days was either tied in a queue, or rolled up in curls; but when drest in their best attire, it was commonly spread over their shoulders. Some of them wore two or three narrow ribbands round their hats, placed at equal distances, in which it was customary with them to insert one or more bunches of primroses or other flowers. Perhaps it will strike a stranger, on passing along the streets of Newcastle on a Sunday or holiday, that the better sort of the inhabitants are partial to poseys or flowers.

The general direction of a large colliery, as to the scale and disposition of its workings, and also with regard to whatever requires a profound theoretical, as well as a complete practical, knowledge of obtaining the coal economically and safely, is in the North

confided to persons called viewers. The *viewer* being not only a person of education, but one who is presumed to have the best information and largest experience as to all matters connected with mining, he is consulted professionally by the coal owners, and in the degree that he is found to possess judgment and integrity, his services are often retained by several independent concerns. Under him is the *overman*, or person who has the sole direction of the underground economy of a pit, visiting it every morning before the men go to work, and keeping a daily account of the labours of the pitmen. He takes his instructions from the viewer, and every person else in the pit is subordinate to him. The office of an overman is of the utmost importance in the management of a coal mine, and none but men of tried experience, integrity, and sobriety should be appointed to fill it. An overman is allowed as many deputies as may be necessary, according to circumstances. The *keeker* is an inspector of the hewers, &c. *Hewers* are the workmen who are actually employed in cutting down the coal in the mine. *Putters* and barrowmen are employed in filling and putting, or pushing* the corves on trams to the crane or shaft. *Drivers* are boys employed to drive the horses. *Trappers* are the youngest class of boys employed to close the doors, which duty is sometimes performed by old men. *Onsetters,* those who hook on and take off the corves below, as the *banksman* does above.

In the collieries in other parts of the country, although the foregoing terms may not be used, the

* The pitman in the North calls his companion *marrow*; hence the line in the Collier's Song—

"As me and my *marrow* were *putting* our *tram*," &c.

workmen are generally divided into much the same parties, though the supervision of the work may be different. In some parts of Staffordshire, the working of a colliery is undertaken conjointly by two men, provincially termed *Butty* and *Doggey*. When a person owning a tract of coal wishes to work it without actual personal direction or superintendence, he sends for the parties above named, who contract to get and raise the coal at a royalty of one-fourth, fifth, or sixth of the proceeds of sale, according to agreement—the owner "putting down the plant," i. e. finding the machinery; so that the undertakers have no property but their labour in the "plantation." The Butty, who is generally the manager of the concern, as representative of the owner, rarely descends the shaft, while the Doggey takes the entire and absolute direction of all the underground operations. These co-contractors are often liberally remunerated, and sometimes amass considerable property, particularly the former, who are also proverbial for their obesity—a Butty and a man with a great belly being terms nearly synonymous among the Staffordshire colliers. When found unsatisfactory, or suspected of dishonesty, they may be "valued out," as it is termed, by a competent reference, the owner in this case paying what may be judged a reasonable bonus to the party displaced. In many instances, however, the coal proprietors manage their collieries as any other concern is managed, namely, through the medium of responsible agents, a ground-bailiff taking the general oversight somewhat in the manner of a Newcastle viewer.

In 1827, a writer in "Knight's Quarterly Magazine" gave a graphic and facetious description of the

Staffordshire colliers, as he noticed them about Bilston. Their figures are tall and robust in an ordinary degree; but their faces are pale and furrowed even at an early age. Their working dress consists of trowsers and tunic of flannel; but their holiday clothes are generally of velveteen, rather profusely decorated with shining metal buttons: like their Newcastle brethren, they pique themselves on their garters, which are of worsted, very gay in colour, and so tied on that a great part, as if by accident, appears below the knee. In the opinion of the writer alluded to, the high cheek bones, and even the dialect of these pitmen, seem to argue them of northern descent. Perhaps, in some remote age, they may have swarmed from the Northumbrian hive, to seize on the riches of—or rather, it ought to be said, to toil amidst the most imminent dangers for the advantage of the Southrons. They have—or rather *had*, for education has innovated upon the custom—among other peculiarities, a practice of designating each other, as well as strangers, by some cognomen derived from the most striking personal peculiarity of the individual; hence such classical appellations as Nosey, Red Face, Bullhead, Pigtail, Spindleshanks, Cowskin, &c. were current among them; and these not as occasional vulgarisms, but applied with a constancy which frequently caused the baptismal and surname entirely to sink in the *soubriquet*, to the no small inconvenience of persons concerned in obtaining the real name of some individual. Ludicrous instances of difficulty and mistake have been mentioned as arising from this practice.

Scarcely, perhaps, less characteristic of the mind and temper of these hardy sons of subterranean toil,

was the striking manifestation of the co-operative spirit which occurred in 1816 among the Staffordshire colliers. About this time, owing to the continued depression of the coal and iron trades, and consequent discharge of workmen, a number of colliers determined amongst themselves to make their case known to Government, and adopted the novel mode of yoking themselves to several waggons laden with coal, having previously drawn up a petition signed by several Magistrates, which they intended to present to the Prince Regent, together with the coal. Accordingly, three teams of this description set out for the metropolis, each waggon having about fifty men yoked to it; whilst others took different directions. One of the waggons proceeded by the route of Worcester, another by Coventry and Birmingham, and the third by Stourbridge. They proceeded at the rate of about twelve miles a day, and received voluntary gifts of money, &c. on the road, as they passed along, declining to *ask* alms: their motto, as placarded on their vehicles, being—"Rather work than beg." To prevent their progress to the metropolis, police-officers were sent from the Home Department Office, who met two of the parties, one at St. Alban's, and another near Maidenhead, and told the men that they had adopted wrong means to procure relief, and persuaded them quietly to return. They were allowed the value of their coals, which were left to be distributed to the poor, and sufficient means were given them to reach their homes. The conduct of these distressed men was most exemplary: they listened with the greatest respect and attention to the advice of the Magistrates, and, after obtaining a certificate of their good behaviour, returned with the waggons

to their families and friends. A similar proceeding took place a few miles from Chester: the Magistrates of that city met the third team, dissuaded the men from further persisting in their ill-advised undertaking, and gave them £20 for the coal, with which they were perfectly satisfied, and immediately returned to their own neighbourhood. The novelty of this affair created some sensation in London.*

Of late years, the ancient relations, so long subsisting between the pitmen and their employers, have been sadly broken down by the operation of circumstances over which, as to their origin, perhaps, neither party had much direct controul. According to the old order of things, immemorial usages were tacitly allowed to have the force of law: the men were regularly hired, spent their money and their lives, with little consideration of what the world was doing around them: sometimes they acted despotically; but their masters grew rich: and this harmony was only broken by occasional riots resulting from accidental causes. The old proverb, setting forth the folly of "carrying coals *to* Newcastle," was duly reverenced; and the practicability of carrying them *from* various other places to London and elsewhere, appeared to excite but little attention. But when the spirit of mercantile speculation was once turned toward the collieries, and new sources of supply were opened up; when competition arose in the market, and the consequent diminution of individual profits, induced the masters to aim at making better terms with the men, the latter sought to strengthen themselves by the dangerous bond of combination; ac-

* Pitt's Topography Staff. 179.

cordingly unions of the pitmen were formed,* and from that moment, a series of conflicts, too painful to

* In 1826, the "Association of Colliers on the rivers Tyne and Wear" consisted of upwards of four thousand persons. The ostensible objects of their Union were "to make provision for themselves and families in cases of death, sickness, or other accidents or infirmities, and to unite in a firm manner, in order to obtain a more suitable recompence for and to regulate the hours of labour." One clause in the Rules of this Union provided "that no member should earn more than four shillings and sixpence per day, while employed underground in the mines;" nor is any one allowed to work as "a hewer, in shiftwork, above eight hours in every twenty-four hours;" nor, when hired by the day, should he labour underground above twelve hours in the twenty-four.

On the other hand, the coal owners of the above districts had also formed themselves into an Union, and required, collectively, a bond, which had for a long period preceding the above date, been customarily signed by the workmen at the time of their annual hiring in the month of March. Many of the clauses of this bond, as well as the method of its promulgation, were held to be serious grievances by the pitmen. It was the custom, instead of giving each man a copy of the document, to read it aloud in the open air, from some eminence, at the time and place of hiring, immediately after which, the parties were called upon to sign the contract—though in consequence of the sounds of disapprobation frequently expressed by the nearer portion of the audience, on the reading of new and unpalatable clauses, those at the outside sometimes could not hear at all. Instead of this reading, they wished to be furnished with copies of the bond a fortnight before the time of hiring.

Their objections in detail had reference to the time of lying idle, the amount and method of collecting forfeits for sending up short measure, or mixing the coal, and some other matters. In order to ascertain that the corves are properly filled, it is stipulated that a tub of the standard measure of the corves to be used at each colliery shall be kept at the mouth of the pit, for the purpose of measuring the contents of any suspected corve which may be sent to bank, and if it shall be found deficient in quantity, no payment is made for hewing and filling the same. This is sometimes a hard case; for the poor pitman, who happens to have sent his corves away from the board unintentionally half-a-peck defective, or from which that quantity may accidentally be scattered, in its passage to the bank, loses the price of getting the remainder, 39 pecks, as, notwithstanding the next corve might contain a peck over, it would not be allowed to go to make up the deficiency.

It is also provided by the bond, that in case any foul coal, splint, or stone, shall be found in any corf, to the amount of one quart, or more, the hewer shall forfeit three-pence per quart; and if the whole quantity shall exceed four quarts, the hewer is adjudged guilty of a misdemeanor, and is subject to a penalty inflicted by law. Moreover, for every corf of good coals mixed with bottom coals, sent to bank, it is covenanted that the hewer forfeit one shilling for every such corf, and one shilling for every corf of round coals mixed with small coals, and sent to bank. To this regulation the pitmen

be dwelt upon, from being in every way disastrous in their consequences, ensued.

As the masters in general no longer felt willing to give the usual bounty or hiring, the men declined to engage themselves, or indeed to work at all, except on their own terms; and hence resulted what, in the language of the north, is called a "stick." But, as always happens in contests of this nature, there were on the other hand, some masters anxious to be served at all events, and in some instances, it may be, actuated by other motives—these were ready to hire the pitmen on high terms: again, there were not a few of the pitmen desirous of labouring for the maintenance of themselves and their families, for such wages as they could obtain, or might think sufficient, who were prevented by intimidations from so

strongly object, "because," say they, "under the terms *foul coal*, the master classes whatever parts of the strata he pleases." Thus, if coal be tainted with red rust, in consequence of the damp air penetrating the pores to a certain depth, it is considered of inferior quality, and therefore called "foul coal:" there is often considerable difficulty attendant on a complete separation of it. When it is effected to the best of a man's knowledge, should he omit to mark the corf that contained the foul coal, or the mark be rubbed off, as sometimes happens, it is set out as finable. When there are two or three bands in a seam, besides the top and bottom stone, it is sometimes extremely difficult to rid the coal of every portion of it, especially with no other light than the faint gleaming of a Davy lamp. As to the mixture of small and large coals, the pitmen declare it next to impossible to send a corf to bank without its being more or less so mixed.

To shew the dexterity with which the colliers can put an extreme case, "suppose," say they, "a man were to work twenty-five fortnights in a year ten days each, and twelve corves each day, at 6s. 6d. per score, he would hew 3000 corves, for which, on the separation system, he would have to forfeit according to the rigour of the bond, 3000 shillings, or £150. As the amount of his earnings on the above calculation, would be only £48 15s. he would consequently, at the end of the year, be indebted to his master £101 5s. besides the total loss of his earnings."—*Appeal to Coal Owners and Viewers, Newcastle*, 1826. The extravagant character of the foregoing hypothesis need not be pointed out: the men, in fact, but seldom, on the whole, expose themselves to fines on these heads, unless there be gross negligence or the intention of wilful fraud.

doing.* Thus it happened that in some of the little colonies above mentioned, ejectments of the tenants,

* Whether the rates of remuneration at which the pitmen were expected to sell their labour to their employers, was too little or not, or whether the latter in every instance dealt fairly with the men, the writer does not profess to be competent to decide; the remarks in the text have merely reference to disasters the existence and origin of which were but too palpable. Neither is it intended by any expression of disapprobation towards combinations for overruling a free trade in labour, to cast any imputation upon associations formed for the mutual relief of their members when labouring under sickness, accidents, or infirmity; the former are essentially mischievous, the latter can hardly become other than beneficial. The coal-owners themselves have always been anxious to promote these Benefit Societies, and connected with the Lambton Collieries, there is one numbering about twelve hundred members. It was established by the Earl of Durham, in January, 1833, for the maintenance of its members in old age, sickness, lameness, or infirmity. It is supported by voluntary subscription; and his Lordship contributes a sum equivalent to one-sixth part of the ordinary contributions of all the members. The first anniversary of this association was celebrated at Lambton Castle, when the committee of management, fifty in number, were hospitably entertained by Lord Durham, who after dinner, addressed the persons present on the subject of combinations. "Sad experience (he said) must have shown you that combinations effected but one object—that of enabling a certain number of cunning and unprincipled men to live at your expense, whilst you were starving, and, at the same time, ruining the trade of the district, which in many cases has been transferred to other parts of the country. The laws of the land were violated, assaults and indecent outrages, nay even murders, were committed, and after perpetuating disturbance and confusion for months, and levying thousands of pounds from the industrious workmen, what was the result? Did wages advance? No, the very reverse. Thousands of additional workmen were brought from a distance, and there being many more hands than could be employed, in the natural course of things, wages were still more lowered. The pretence for these unions has been to raise wages; the real effect had been, not the advance of the rate of wages, but merely the support of those delegates for a limited time in idleness and luxury. These men know, or ought to know, that the rate of wages depends on the price which is given by the public for the article worked. Now, the price of coals is very low, so much so, that little or no profit is made by the coalowner. In many instances he actually loses, and pays the wages of his men out of his capital, not out of his profits. Be assured that if prices rise, wages rise as a matter of course; but that if prices fall wages must also fall, and that it is as impossible for the master to pay his men advanced wages when prices are low, as it would be for you to pay your butcher and grocer higher prices for meat and tea and sugar whilst your wages are low. If any of these delegates tell you that the coalowner has been making great profits, out of which he could afford you a higher rate of wages, he has grossly deceived you. In no trade is there less regular profit and more steady and permanent expense. In fact, capital invested in the coal trade

vi et armis, were going on, while in another place personal injuries were dealt out to the unfortunate individual who might be disposed to resume work without leave of the " Committee."

The inhabitants of Newcastle-upon-Tyne, and those in the immediate neighbourhood, will not soon forget the " stick" of the pitmen in 1832; nor can the latter, as a body, presently recover from the sufferings they brought upon themselves. All the frightful evils resulting from a misunderstanding of the nature above alluded to; aggravated as they were, by a strongly organised power of resistance on both sides, were almost daily exhibited through a considerable portion of the year. When these men had *struck work* some time, and there appeared no likelihood of any agreement being come to between them and the masters, the latter circulated advertisements in the remote mining districts, inviting workmen to come down to the north to take the place of the turn-outs, holding forth at the same time the fairest prospects of good wages and personal protection: the pitmen, in turn, distributed themselves through the country, and sought by every means in their power to counteract the effect of these flattering inducements—and one of their modes of doing this was by the publication of a broad-sheet list of the accidents "by fire and flood," which had, at various times, occurred in the collieries on the Tyne! Notwithstanding this, great numbers

affords less interest than almost any other, with more hazard and uncertainty. At the present moment most collieries are conducted at no profit at all, or at a loss; and if this state of things continues, will have to be shut up. It is in these circumstances that men are going about endeavouring to raise unions in order to raise the rate of wages. Their success would entail the shutting up of many collieries, and the consequent spreading over those remaining all the unemployed hands. The result, I need not tell you, would be a still greater reduction of wages."

of persons, particularly from Wales, left their houses, removed their families, and went to work in the north. The northern coaches were crowded with the adventurers, and the stage-waggons were piled with their bedding and boxes: many from the shorter distances of Staffordshire or Yorkshire, walked or hired light vehicles—and certainly to see the numerous haggard pedestrians, or the cart loads of squallid women and children, in and about the town of Newcastle, going and returning, was a grievous sight! Many of the strangers found matters so little flattering, that they hastily bent their steps back again; others staid and entered upon their work; not a few, especially of the Welsh strangers, fell victims to the cholera, which raged sorely at several of the collieries; in almost all cases, the condition of the new comers was irksome in the extreme. It was no uncommon thing to see the native pitmen idly reposing on the grass, or unaccountably traversing the neighbourhood, while a policeman with a drawn sword in his hand, or a firelock on his shoulder, was walking to and fro, on the adjacent pit-hill, to protect the party at work within! The police were out every night on duty about the several collieries, to prevent damage to the works or outrage to the men.

It was not to be supposed that in a state of things like this, however discreetly the bulk might act—and certainly the conduct of many was irreproachably peaceful—that all the parties who were so highly excited, would demean themselves in such a manner as not to be overtaken in any direct breach of the law. Unfortunately, some very heinous offences, including two or three murders, were perpetrated. The writer cannot forget his feelings when, one evening, re-

turning from the delightful marine village of Tynemouth to Newcastle, during these disturbances, and seeing a crowd about a public-house, he enquired what was the matter, to receive for reply—"the police have shot a pitman!" This turned out to have been really the case, in a fray that had just ended. Another case, which created considerable interest at the time, not only in the neighbourhood of the collieries, but throughout the country, was the murder of Nicholas Fairless, Esq. a highly respectable and humane Magistrate of South Shields, by two pitmen of the names of Jobling and Armstrong. The last named culprit succeeded in getting out of the country; but Jobling was taken, tried, and executed at Durham, and afterwards, pursuant to his sentence, hung in irons on a gibbet, in a mere called "Jarrow Slake," and within a few score yards of the spot where the fatal act had been committed. This gibbet was particularly obnoxious to the pitmen; and various rumours circulated to the effect, that it would never be allowed long to remain an object of horror to so intrepid a body of men. A few weeks afterwards, the writer of this notice, and a friend with whom he was walking along the head of the Slake, were struck with the altered appearance of the gibbet, and on approaching it they ascertained from various parties, that during the preceding night, the tall post had been ascended, the end of the transverse piece sawed off, and the body carried, as was supposed, out to sea, and there sunk: no tidings either of it, or the persons concerned in the unpleasant and daring enterprise, were ever received.

CHAPTER XVI.

THE COAL TRADE.

Fossil Coal little if at all known to the nations of Antiquity — Mentioned by Theophrastus — Supposed to have been used by the Ancient Britons— Old Cinder Heaps—Coal mentioned by Saxon Authors—Extract from the "Bolden Book"— Charter to the Inhabitants of Newcastle to dig Coals—Sea Coal—Evidence of Early Modes of Working—Hostemen—Earliest Notice of Exportation of Coals—Charitable Donations of Coals —Formerly burned along with Wood—Early states of the Coal Trade—Richmond Shilling—Complaints of the decrease and waste of Fire-wood— Historical Notice of the Introduction of Pit Coal into common use—Evelyn's Lamentation on the Decay of Forests—Coincidence in the Deposits of Coal and Ironstone—Difficulties encountered in substituting Pit Coal for Charcoal in making Iron —Notices of the Coal Trade on the Rivers Tyne, Wear, and Tees.

IT is hardly possible to contemplate the prodigious amount of manufacturing power and domestic convenience dependent on the produce of our coal mines,

without wishing to know something of the introduction of so invaluable a source of national wealth and comfort. It is, however, a singular circumstance, that we are met on the very threshold of the enquiry with two unwelcome facts—first, that there is almost as much obscurity as brevity in the notices on this subject which occur in our elder writers; and—second, that the use of pit-coal,* in a large way, appears to have no claims to very high antiquity, either in this or any other country.

Authors appear to be agreed that, the earliest express mention of fossil coals, used as a fuel by artificers, occurs about two thousand years ago, in the writings of Theophrastus, the scholar of Aristotle, who, in his Book on Stones, gives the subsequent very particular description of them :—"Those fossil substances, that are called coals, and are broken for use, are earthy; they kindle, however, and burn like wood coals. These are found in Liguria, where there is also amber, and in Elis, in the way to Olympias over the mountains: they are used by the smiths."†

* Perhaps it may not be useless to remark that the word *coal*, or as it was formerly more commonly written *cole*, did not originally signify fossil fuel, with which meaning, however, it is now generally identified, but wood or other matters used for fires. In this sense the term occurs repeatedly in the English Bible: and Thomas Britton, the noted musical "small coal man," was so called, not because he sold broken pit-coal, but little bundles of chopped wood or sticks, used for kindling fires in London. Coal, is represented in several of the languages of Northern Europe by words similar in sound, as *col*, Saxon; *kol*, German; *kole*, Dutch; *kul*, Danish, &c.

† Hill's Theophrastus, p. 62. On this passage, the translator has the following remarks:—"The substance here described, whatever mistakes there may have been among authors since about it, appears to me to be evidently no other than the common pit-coal; and I have made it appear as clearly so in the translation, only by having properly rendered the word ανθρακεις, the carelessly misunderstanding of which word alone, has been the occasion of all the erroneous guesses about the substance here described. The authors of these seem all to have understood the word ανθραξ, as signifying fossil or pit-coal; and, therefore, as the author compares the burning of this

Sicculus Flaccus says, that coals, among other things, were used for landmarks; and St. Augustine describes them as applied to that purpose on account of their imperishable nature—a singular assertion, truly: "they who pitch them," says he, "are wont to throw them underneath, to convince any litigious person, who should affirm, though ever so long after, that no land mark was there."*

Whether or not the aborigines of this island had any knowledge of the coal so abundantly discovered in later times, is a question that has been repeatedly discussed. Whitaker, in his History of Manchester, is of opinion that the primœval Britons used coal. He argues first from the probability of their discovering it: "Our currents," says he, "frequently bring down fragments of coal from the mountains, the extremities [of the strata] rising into daylight, and being washed away by the rains and rivulets,—the Britons would soon mark the shining stones in the channels, and by the aid of accident, or the force of reflection, find out the utility of them. But we

substance to that, they were necessitated to think of some other substance that he might here mean, as it was impossible he should intend to compare a thing with itself. Wormius, on this foundation, imagined that he meant the cannel coal. Quod Galenus vocat ampletidem, &c. Theophrastus vocat carbones, quod eorum colorem habeat et vices gerat. Thus is Theophrastus, according to custom, accused of saying things he never meant; because the people who quote him have not been at the pains to understand him: εκκαιονται δε και πυρυνται καθαπερ οι ανθρηκες, is evidently, they kindle and burn like wood-coals, or, as we call it charcoal; for that is the genuine and determinate sense of the word ανθραξ in Greek, and carbo in Latin; as is evident from other works of this author, Pliny, and all the other old naturalists. Even the more correct of the moderns, when they would express what we call pit-coal, the substance here described by the author, never use the words ανθραξ or carbo alone, but always carbo fossilis, and λιθανθραξ. The similar use of this bitumen got it the name of coal, but always with an addition that distinguished it from what was more commonly and properly so called, that expressed its not being of vegetable but fossil origin."

* Lib. d. Civ. Dei. 21, c. 4.

can advance still nearer to a certainty: several pieces of coal were discovered a few years ago in the sand under the Roman way to Ribchester," &c. "That the Britons," he proceeds, "were acquainted with this fuel, is evident from its appellation amongst us at present, which is not Saxon, but British, and subsists among the Irish in their Guel, and among the Cornish in their Kolon to this day." In addition to this, we are further told by Pennant, that a flint axe, the instrument of the Aborigines of our Island, was discovered stuck in certain veins of coal, exposed to day in Craig y Larc, in Monmouthshire, and in such a situation as to render it very accessible to the unexperienced natives, who in early times were incapable of pursuing the seam to any great depth.* These statements are respectively unsatisfactory, when opposed to the mere presumption that had so early a discovery of the accessibility and use of coal really taken place, they would not again have been lost sight of, or at best so little regarded.

It is said there are no beds of coal in the compass of Italy; yet the strongest argument in favour of the opinion of those,† who think that the Romans while in Britain, were ignorant of it, is, that there is no name for it in their language, the genuine and determinate sense of *carbo* being charcoal. Cæsar, although he mentions the existence of metals, is silent concerning coal, in his description of our Island. That these shrewd people afterwards discovered and used coal can scarcely be doubted. "The Romans," says Whitaker, with great confidence, "appear actually using coal in Britain. In the West Riding of Yorkshire, and neighbourhood of North Brierly, are

* Pennant's Tour in Wales, p. 17. † Brand's Newcastle, vol. ii. p. 249.

many beds of cinders, heaped up in the fields, in one of which a number of Roman coins was found some years ago." Similar indications have been met with elsewhere. Horsely, in the Britannia Romana, speaking of some inscriptions found at Benwell, a village near Newcastle-upon-Tyne, and the Condercum of the Romans, remarks, " that there was a coalry not far from that place, which is judged by those who are best skilled in such affairs, to have been wrought by the Romans."* It is also the opinion of Wallis,† that " the Romans were as well acquainted with our pit-coal, as with our ores and metals: in digging up some of the foundations of their walled city Magna, or Caervorran, 1762, coal cinders, some very large, were turned up, which glowed in the fire like other cinders, and were not to be known from them when taken out."

Toward the middle of the ninth century we find ourselves on less doubtful ground. Whitaker, in his History of Manchester, mentions a grant of some lands made by the Abbey of Peterborough, dated A.D. 853, which proves, as it should seem, that this fuel was known, and in use amongst us, while the Saxons were masters of Britain. By this grant, certain boons and payments in kind were reserved to the Monastery, as one night's entertainment. Ten vessels of Welsh, and two of common ale; sixty cart-loads of wood, and twelve of fossil, or pit-coal: the words in the original are twælf foður græfan, translated by Bishop Gibson, " duodecem plaustra carbonum fossilium."‡ No mention of this fossil occurs under the Danish usurpation; that people, indeed, as

* Brit. Rom. p. 209. † Hist. Northumb. vol. i. p. 119.
‡ Saxon Chron.

Brand justly remarks, were too much perplexed, during their stay in this country, by civil commotions, to have had leisure to attend to any thing but what was obvious, and to be purchased with little trouble. So that wood would naturally be the chief article of fuel, while immense forests and thickets presented themselves to yield an abundant supply. It may be mentioned, that in the "Bolden Book,"—a sort of Doomsday record of the County of Durham—composed before A.D. 1195, we find that among the allowances to the tenants in villenage at Bishop Wearmouth, "the smith has twelve acres for the iron-work of the carts, and finds his own coal—*carbonem*." * For a few reigns after the Norman Conquest, during which time, our unhappy country was perpetually, as it were, under fire and sword, the same silence, which must be attributed to the same causes, prevailed concerning fossil coal.

December 1st, 1239, King Henry the Third is said† to have granted a charter to the townsmen of Newcastle-upon-Tyne, for liberty to dig coals and stones—perhaps grind-stones—in the vicinity of that place.‡ This licence, which issued on the supplication of the parties interested, is the earliest direct notice of the actual working for coals extant: for, in the Leges Burgorum of Scotland, which were enacted about the year 1140, although a particular privilege

* Surtees' Durham, i. 224.

† Gardner's England's Grievance Discovered, p. 9.

‡ Namely in "the Castle Field, and the Forth." Neither of these spots exhibit at the present day any traces of such operations as are implied by the grant: the former locality would be built over, at an early period, and the latter has been noted for about a century as a fashionable promenade of the townspeople: but the fine lime trees with which it is still overshadowed exhibit symptoms of decay only less signal than that which has overtaken the custom with which they have been cotemporary.

is granted to those who bring fuel into boroughs—wood, turf, and peat are expressly mentioned—there is no account of coal: these laws were made at Newcastle-upon-Tyne.* The strongest and most unequivocal proof, however, that this species of fuel was in use amongst us during the reign of Henry the Third, is to be found in an inquisition preserved among the additions to Matthew Paris's History, of the date of 1245. Here we find it called *carbo maris*—sea coal—an appellation retained through succeeding centuries†—with express mention of making pits to win it, and of the wages of the colliers that wrought in them. We have an incidental mention of "coal," in reference to its use in the southern part of England, during the reign of Edward the Second; for, in an account book of the servants of the Archbishop of Canterbury, who resided alternately at Lambeth and Croyden, occurs this entry, "thirty cart loads of coal from Burstone to Croyden."‡ In the year 1281, according to an authority quoted by Brand, there had been so rapid an increase of the

* Leg. Burg. c. 38, quoted in Arnot's Hist. Edinburgh.

† The term in the text, although it has been so long in use, appears generally to have had no other meaning than as signifying sea-borne coals, in opposition to such as were dug inland. Leland, in his Itinerary, vol. viii. p. 19, has the following passage: "The vaynes of the se-coles ly sometyme upon clines of the se, as round about Coquet Island, and other shores; and they, as some will, be properly called se-coles; but they be not so good as the coles that are digged in the inner part of the lande."

‡ Assuming, that fossil coal is meant by the term used in the above entry, we agree with a writer in the Athenæum who observes that the reference is curious, as Croydon was almost surrounded with wood, and as coal, excepting at London and a few other towns, was scarcely ever used: it becomes therefore probable that this fuel was for the Archbishop's own use in his private chamber, as such rooms, about the period in question began to have the convenience of chimneys and enclosed fire places. These thirty loads of coal appear to have cost 53s. 9d. a high price, when it is remembered, that the wages of a master-carpenter were but 4d. *per diem*, and wood might be had almost for the trouble of carting it.

coal trade at Newcastle, that, had not that town been granted before by King John at a fee-farm of one hundred pounds per annum, payable to the Crown, that sum would probably have at least been doubled to the then burgesses. From this early period, the History of the Coal Trade becomes almost identical with that of the flourishing town from which supplies of coal have ever since continued to be so abundantly drawn.

Of the methods adopted for working the coal in those early times we have no information: the first attempts would doubtless be on the exposed basset edges of the strata. Mr. Mammet states that evidences of early operations have been discovered near Ashby:—"In Measham, where the bed was not more than forty or fifty feet from the surface, indications of ancient workings were found, in stone hammer heads, and large wedges of flint with hazel withes round them; also wheels of solid wood about eighteen inches in diameter." This statement, if correct, would lead us back to a very early period indeed. It is probable that delving in some shape would lead to making vertical shafts, as the latter led to horizontal excavation. A "coal mine" is mentioned in the ordination of the Vicarage of Merrington, in the county of Durham, in 1343; and in 1354 there is extant a notice of the "sinking of pits" at Ferryhill, in the same county.*

Brand, in his interesting History of Newcastle-upon-Tyne, has detailed in a chapter on the "Society of Hostmen," Ostemen, or fitters,† the parti-

* Surtees, iii. 396.

† This term is at present used of those who "fit" or load coals on board the vessels in the river—a sort of factors between the owners a .d purchasers of the commodity. It is observable, says Brand, that the title of this fra-

culars of most of the legislative and municipal regulations of the coal trade up to 1789, the time when he wrote. Such extracts therefrom, as well as such other notices connected therewith, as may be most likely to interest the general reader, shall be given. We have no distinct notice of the earliest shipment of coal for London, though, as we shall afterwards find, the use thereof in the Metropolis, was prohibited in 1306, by Royal proclamation! Nevertheless, within about twenty years afterwards, it appears to have been used in the Royal Palace; as in the "Petitiones in Parliamento," A.D. 1321—1322, a claim is made for ten shillings, on account of fuel of that sort which had been ordered by the Clerk of the Palace, and burnt at the King's Coronation, but neglected to be paid for. A.D. 1325, a vessel, the property of one Thomas Rente, of Pontoise, a town in the antient dominions of the Kings of England, in France, is mentioned as trading to Newcastle-upon-Tyne with corn, and returning with a freight of sea coals.

In the year 1327, the measure of sea-coal having become an object of consideration, we may infer that this fuel was regarded as an important article in the commerce of that time:* in the next century

ternity, is often in the printed Journals of the House of Commons, misspelled "fillers." The more ancient designation of *Hostemen*, long borne by this society, is of uncertain etymology: some have derived it from the Latin *oustmanni*, i. e. eastmen, either from their trading to the eastern parts of Europe, or from their intercourse with men from the coast of Germany in that quarter. It appears from the earliest entries in the books of this Society, that the stranger arriving at the port of Tyne to buy coals, is called "the Oaste."

* The Monks dabbled in mining speculations; hence we meet with the term "coyle," in Abbey leases. Tynemouth Priory had a colliery at Elswick, which in 1330, was let at the yearly rent of five pounds; in 1530, it was let for twenty pounds a year, on condition that not more than twenty chaldrons

the still growing consequence of the trade is indicated by the terms of an Act of Parliament, in which it is set forth, "that whereas there is a custom payable to the King of two-pence per chaldron on all coals sold to persons not franchised in the port of Newcastle, and whereas the keels which carry the coals from the land to the ships in that port, ought to be of the just portage of twenty chaldron, according to which burden the custom aforesaid is paid; yet many are now making their keels to hold twenty-two, or twenty-three chaldrons, the King is thereby defrauded of his due: Wherefore it is now—[May 2, 1421]—enacted, that all keels be measured by Commissioners to be appointed by the King, and to be marked of what portage they be, under pain of forfeiting all the said keels which shall be found not marked."

Æneas Silvius, who afterwards assumed the purple under the name of Pius the Second, visited this island about the middle of the 15th century. He relates, seemingly with some surprise,* that he saw in Scotland poor people in rags begging at the Churches, and receiving for alms, pieces of stone, with which they went away contented. "This species of stone," says he, "whether with sulpher, or whatever inflammable substance it may be impregnated, they burn in place of wood, of which their country is destitute." Doles of this, and other kinds

should be drawn in a day; and eight years after, at fifty pounds a year, without any restriction as to quantity to be extracted. [Brand, ii. 255, 264.] In Richard the Second's time, Newcastle coals were sold at Whitby at 3s. 4d. per chaldron: [Charlton's Whitby, p. 260]—and, in the time of Henry the Eighth, their price was "twelvepence" a chaldron in Newcastle; in London "about four shillings;" and "in France they sold for thirteen nobles per chaldron."

* Ænei. Sylvii Opera, p. 443; and Arnot's Hist. Edin. p. 82.

of fuel, are still annually distributed in various parts of this country in the winter season: nor is this by any means one of the least acceptable forms under which charity presents her gifts to the poor.*

In the celebrated "Household Book" of the fifth Earl of Northumberland, of the date of 1512, a record, as Brand justly remarks, of singular curiosity, equally throwing light on our ancient manners, and reflecting lustre on the great family whose extensive plan of domestic economy it so minutely displays, mention occurs of this description of fuel, which it seems they had not yet learnt to use by itself, for the following extraordinary reason, "bicause," observes this authority, "colys will not byrne without wodd." Eighty chaldrons of sea coal, at 4s. 2d. and 5s. the chaldron were allowed in the year; and also sixty-four loads of great wood, to make the coals burn. This last circumstance seems to prove, says Brand, that the coal owners had not yet discovered, or found means to win the deep strata of this fossil, or what is styled in the language of the trade "the main coal." Some notices of the trade to foreign countries, at an early period, will be found in a subsequent chapter. It may, however, be remarked that towards the end of the prosperous reign of Queen Elizabeth, the coal trade flourished greatly, and continued to be regarded

* Donations of coals are very common in several of the colliery districts; nor were these always confined to the poor: in the earlier periods of the coal trade, the Municipal Authorities as well as the Hostemen of Newcastle, were in the habit of sending presents of the staple commodity of the town to their friends in London: this custom of transmitting "gift coals," was wholly laid aside before the end of the seventeenth century. A "keel of coals," however, is the ordinary and acceptable present of a Northern coal owner, to a local charity; and it is worth recording that the late Mrs. Oliver, of Long Melford, Essex, who died in 1833, left by her will, the interest of £4,000 stock, to be laid out in coals, and distributed twice a year for ever, to the poor of that place, by the churchwardens and overseers for the time being.

as an important source not only of local but of government revenue by succeeding monarchs. The arbitrary taxes imposed on this trade, and the shameful monopolies authorised by royal cupidity, contributed materially, as is believed, to induce the downfal of Charles I. After the Scottish armies took Newcastle, the House of Commons began to direct the coal trade, and govern the town; by which step, they were enabled to send for the use of the poor of London large supplies of coals, which had "risen to the price of four pounds per chaldron." Notwithstanding this seasonable interference of the ruling powers, fuel was so excessively dear in the Metropolis in 1648, that many poor people were starved to death—a calamity which was charged upon the Governor of Newcastle, for the severe imposition of four shillings per chaldron upon coals.

At a shortly subsequent period, the prospect of extraordinary gain led various adventurers to speculate in working the mines in the Northern counties. An eye witness thus describes the state of things:—"Many thousand people are employed in this trade of coales: many live by working of them in the pits: many live by conveying them in waggons and wains to the river Tine: many men are employed in conveying the coals in keels from the stathes aboard the ships: one coal merchant employed five hundred or a thousand in his work of coals: yet for all his labour, care, and cost, can scarce live of his trade: nay many of them hath consumed and spent great estates, and dyed beggars. I can remember one of many that raysed his estate by coale trade: many I remember, that hath wasted great estates. Some south country gentlemen have, upon great hope of benefit, come

into this country to hazard their monies in coale pits. Master Beaumont, a gentleman of great ingenuity, and rare parts, adventured into our mines with his thirty thousand pounds; who brought with him many rare engines, not known then in these parts—as the art to bore with iron rods, to try the deepnesse and thicknesse of the coale, rare engines to draw water out of the pits, waggons with one horse, to carry down coales from the pits, to the stathes, to the river, &c. Within few years he consumed all his money, and rode home upon his light horse."*

Duties were laid upon sea borne coal, to assist in building St. Paul's church, and fifty parish churches in London, after the great fire in that city; and in 1677, Charles the Second granted to his natural son, Charles Lenox, Duke of Richmond, and his heirs, a duty of one shilling a chaldron on coals, which continued in the family till it was purchased by Government. This impost, so troublesome to the Tyne coal-merchants, and long known as the "Richmond shilling," produced, soon after it came into the hands of Government, £25,000 a year.†

In 1699, Newcastle had two-thirds of the coal trade, and 300,000 chaldrons, in all, went annually to London. The oversea trade employed 900,000 tons of shipping. Coals about that time sold in London for eighteen shillings a chaldron, out of which five shillings were paid to the king, one shilling and sixpence to St. Paul's, and one and sixpence

* Grey's Chorographia, p. 24.

† It was purchased of the Duke of Richmond by Government in 1799, for the sum of £400,000; since which time, the whole amount, allowing 5 per cent. per annum interest, has been more than redeemed by the income, an overplus of £341,900 having accrued to the purchasers. It was relinquished by Government, March 1, 1831.

metage. It was then also stated to the House of Commons that six-hundred ships, one with another of the burden of eighty Newcastle chaldrons, with 4,500 men, were requisite for carrying on this trade. There were also then employed on the Tyne, four hundred keels, and from fifteen to sixteen thousand keelmen.*

The subsequent extracts from Harrison's Description of England, prefixed to Hollingshead's Chronicle, edited in the year 1577, contain some very curious and interesting notices concerning the coal trade; and though they have frequently been wholly or in part cited by writers describing the changes of manners in this country, they are too pertinent to our subject to be omitted in this place. "Of colemines we have such plenty in the north and western parts of our island, as may suffice for all the realme of Englande. And soe must they doe hereafter indeede, if wood be not better cherished then it is at this present: and to say the truth, notwithstanding that very many of them are carryed into other countryes of the maine, yet theyr greatest trade beginneth to growe from the forge into the kitchen and halle, as may appear already in most cities and townes that lye about the cost, where they have little other fewel, excepte it be turfe and hassocke. I marvayle not a little that there is no trade of these into Sussex and Southamptonshire, for want whereof the smiths do work their yron with charre-coal. I think that farre carriage be the only cause, which is but a slender excuse to inforce us to carry them unto the mayne from hence.

"I might," continues our authority, "here take

* Brand. ii. 304.

occasion to speak of the great sales yerly made of wood, wherby infinite deale hath been destroyed within these few yeres,* but I give over to deale in this behalfe; howbeit, this I dare affirm, that if woodes doe goe so fast to decay in the next hundred years of grace, as they have done and are like to do in this (sometymes for increase of shepewalkes, and some mayntaynaunce of prodigalitie and pompe, for I have knowne a gentleman that hath borne three-score at once in one paire of galigascons, to shew his strength and bravery,) it is to be feared that brome, turfe, gal, heth, brakes, whinnes, ling, dies, hassocks, flaggs, straw, sedge, reede, rush, and sea-cole, will be good marchandise, even in the citie of London, wherunto some of them alreadie have gotten readie passage, and taken up their innes in the greatest merchaunt's parlers."

This quaint writer goes on to contrast the manners of former times with those of his own: "Now we have many chimnyes, and yet our tenderlings complaine of rewmes, catarres, and poses; then had we none but reredoses, and our heads did never ake. For as the smoke in those days was supposed to be a sufficient hardning for the timber of the house, so it was reputed a far better medicine to keep the good man and his family from the quacke or pose, wherewith, as then very few were acquainted." Our historian proceeds: "There are old men yet dwelling in the village where I remain, which have noted the

* This wastefulness of timber was a topic of lamentation with the poets. Old George Wither, in the motto under one of his curious "Emblems," (published 1634,) tells us with what feelings he beheld

"——— The havoc and the Spoyle,
Which, ev'n within the compass of my dayes,
Is made through every quarter of this Ile,
In woods and groves, which were this kingdom's praise."

multitude of chimnies lately erected, whereas in their yoong dayes, there was not above two or three, if so many, in most uplandish townes of the realme, (the religious houses and mannour places of their lordes always excepted, and peradventure some great personages,) but each one made his fire against a reredosse in the halle where he dined and dressed his meate"—he then, with something like bitterness, adds "when our houses were buylded of willowe then we had oken men, but nowe that our houses are come to be made of oke, our men are not only become willow, but a great many altogether of straw, which is a sore alteration."

About fifty years afterwards, the apprehensions of Harrison relative to the decay of wood fuel, appear to have been realized: the grown timber had not only been generally wasted, but there had been an unthrifty neglect in not planting fresh trees. This want of wood, however, not only brought pit-coal into more common use for domestic household purposes, but likewise, in a manner compelled the adoption of it for other more important uses, as mentioned by one of our annalists. "Such," says Stowe,* "hath bene the plenty of wood in England for all uses, that within man's memory it was held impossible to have any want of wood; but contrary to former imaginations, such hath been the great expense of timber for navigation; with infinite increase of building of houses, with the great expence of wood to make household furniture, casks, and other vessels not to be numbered, and of carts, waggons, and coaches; besides the extreame wast of wood in making iron, burning of brick and tile; that whereas in the year of our Lord God

* Stowe's Annals by Homes. Lond. 1632. folio, p. 1025.

1306, King Edward I. by proclamation prohibyted the burneing of sea-coale in London and the suburbs, to avoid the sulferous smoke and savour of the firing, and in the same proclamation commanded all persons to make their fires of wood; which was performed by all (Smith's only excepted); yet at this present, through the great consuming of wood as aforesaid, and the neglect of planting of woods, there is so great scarcity of wood throughoute the whole kingdom, that not only the city of London, all haven townes, and in very many parts within the land, the inhabitants in general are constrained to make their fiers of sea-coale or pit coale, even in the chambers of honourable personages; and through necessitie, which is the mother of all arts, they have of very late years devised the making of iron, the making of all sorts of glass and burning of bricke with sea coal or pit coal.—Within thirty years last, the nice dames of London would not come into any house or roome where sea coales were burned,* nor willingly eat of

* A similar prejudice prevails at this day in some parts of France. Mr. St. John, in his "Journal of a Residence in Normandy," mentions that Dr. Bennett, the Protestant Clergyman, told him "that he had received orders to quit his house, *because he burned coal*; and another English gentleman at Caen, who had invited a large party, finding his drawing room very thin, and enquiring the reason, found the French had staid away *because it was understood he burned coal.* What renders the preference for wood fires more astonishing is, that besides giving much less heat than coal, they are far more expensive." Unpleasant as the fume arising from pit coal must be to persons unaccustomed to it, the combustion of fresh wood must often be little less unacceptible to others, on account of the pyroligneous acid evolved: some billets, however, are perfectly free from such objection, while others are even odorous. An elegant and acute observer has mentioned that the wood of the ash, when burned in a green state, will emit a fragrance like that which proceeds from the violet or mezerion, and that this odour will diffuse in particular states of the air to a considerable distance, a property believed not to be observable in any other British wood: it is in the country only that we can be sensible of this—and it is particularly to be perceived in passing through a village when the cottagers are lighting their fires, or by the farm house, when

the meat that was either sod or roasted with sea-coal fire."

The foregoing extract indicates, with striking correctness, how great a revolution was at that time taking place in the application of fuel, not only with reference to the arts, but also for domestic purposes: the abandonment of wood, as an article of firing to which the people had been immemorially accustomed,* was an affair not of choice but of stern necessity: indeed it is amusing to perceive with what bitterness some of the writers of the earlier part of the seventeenth century, inveigh, not only against the increase of those avocations which led to the large consumption of wood, but more especially against the introduction of that very coal, but for the timely and exhaustless supply of which, it is not easy to conceive of the state in which manufacturers as well as housekeepers must have been placed. About the period here alluded to, the British iron-trade, which has subsequently assumed an importance commensurate with the superiority of our national skill, and the extent of the mineral resources of the island, was beginning to be pursued by men fairly awake to its advantages. To meet this growing spirit for the

this wood, fresh cloven, or newly lopped off, is burning; as the wood dries this sweet smell is in a great measure exhaled with the moisture, for in this state we are not sensible of any odour arising from it different from other woods.

* Refuse and rotten timber, or small gnarled trees of no value for the carpenter, still constitute the greater part of the ordinary firing in many districts of this country: indeed, every tract of woodland yields two descriptions of fuel; namely, *Cord-wood*, or that which is laid in stacks during the felling season for the purposes of the charcoal burner, and consisting mostly of such bough-loppings and other waste, as cannot be turned to better account; and *Brush-wood*, which, comprising rammel or spray, briers, and other matters collected in brushing the ground, is bound with withes into kids or bundles, and sold to the bakers and others.

smelting of the native ores, at a time when wood charred or green was deemed indispensible, an enormous sacrifice of our forest timber was required: so much so, indeed, that Evelyn, one of the most amiable of writers, complains most severely that such should be the case, in his "Sylva," an interesting and delightful work on Forest Trees; he remarks that, "Nature has thought fit to produce this wasting ore (of iron) more plentifully in woodlands than any other ground, and, to enrich our forests to their own destruction;" to which he elsewhere adds his "*diræ*, a deep execration of iron mills, and almost of iron-masters too." Mr. Hunter, after quoting the foregoing sentence,* exclaims, "How would he have rejoiced to have witnessed the day when the coke of pit-coal became substituted for the charcoal in this consuming process!"

It is a remarkable fact that the coincidences of locality which Evelyn has so feelingly deplored as existing between our forests and the great depositories of iron-ore should, in reality and to an immense extent, hold good when applied to the geological relations of the latter substance to pit-coal. This circumstance, although well known to the practical iron-workers in this country, appears to have excited less attention among scientific men in Great Britain than in France, where the enquiries of Descostils into the nature of the argillaceous ores of iron, led him to take a just view of this mineral phenomena in its most important bearings. Although the specimens of iron ore examined by this ingenious chemist, had been collected from very different localities in France and also from England, they all agreed in one respect,

* Hallamshire, p. 17.

that they had been found in districts abounding with coal. And the whole of his researches led to the conclusion that there subsisted a very intimate geological connection between coal and the argillaceous carbonate of iron; a connection so close, that the miner might almost with certainty regard the presence of the one mineral as a proof of the vicinity of the other. "But it is difficult," says Dr. Colquhoun,* "to overcome the force of a rooted prejudice: although the memoir of Descostils must at once have carried conviction to the minds of men of science, that the most useful ironstone was co-existent with the beds of coal in the various coal districts of France, yet the nation at large, for a long period, refused to believe that they possessed such a treasure within themselves, and obstinately persisted in regarding the island of Britain as the envied and exclusive depository of that ore."

How largely the theory indicated in the preceding paragraph receives confirmation from the working of British mines, will appear if we only advert to the vast iron foundries in the counties of Stafford, Salop, York, and Derby, as well as to those in several districts of Scotland, and especially in South Wales, where the iron works of Monmouth and Glamorgan are the largest in the world.

It was the general introduction of charred pit-coal, or coke,† during the last century, and which was

* Memoir on Argillaceous Iron Ore, Edin. Journ. of Science, vol. vii. p. 224.

† In Rymer's Fœdera there occurs, in reference to the projected monopolies of the year 1627, a charter to three persons for the sole practice of their new invention for the melting of iron ore, and making the same into cast marks and bars, with sea-coal and pit-coal only. Three years afterwards this project was itself far outdone by that of another company to whom the King granted an exclusive patent for a "new invention for melting, forging, or fining iron, lead, tin, and salt; as also for the burning of bricks, tiles,

obtainable under such favourable circumstances in almost immediate connection with the iron ore, that not only arrested the destruction of our forests, but laid anew the foundation of our present extensive manufactures of native iron; these, we find, were in a flourishing condition in the reign of James I.; but from that time the increase of inhabitants and of cultivation, and the subsequent decrease of wood, caused this business to decline so greatly as to be nearly lost, until the substitution of mineral coal, and the construction of larger furnaces, restored to our country this important trade.

The earliest unequivocal indications of success were in the operations of a person of the name of Dudley, a noted projector, who lived during the civil wars. It was not, however, until a much later period, and after numerous experiments by different individuals with very partial success, and often at a ruinous expense, that the use of pit-coal was fairly recognised. The celebrated works of Colebrook Dale, in Shropshire, were established about 1740, and after some difficulties had been overcome, they were attended with complete success.* The working of these furnaces led to the establishment of others in various places, for smelting iron with charred pit-coal, or coke: for a while, the failure of managing any concern was attributed to some peculiarity in the Shropshire coal; but as the methods of preparing and using the fossil fuel became better understood, establishments rapidly sprung up in

lime, &c. with the fuel of peat and turf, reduced to a coal, without the use of sea-coal, pit-coal, or wood."

* In the Philosophical Transactions for 1747, there is an account by the Rev. Mr. Mason, of what he saw and heard at Colebrook Dale, relative to experiments then and there going on.

almost every district where coal and ironstone abounded; and thus were laid the foundations of that immense and lucrative trade in the smelting, casting, and working of iron, which in this country gives employment to so large a portion of the industrious population.

As might be expected from what has been stated, "the history of our iron trade during what may be considered the era of transition from the use of charcoal to pit-coke, abounds with disastrous notices of the men who embarked on that sea of adventure, the confessedly hidden riches of which appeared perpetually to tantalise one and another with the hopes of discovering, under the form of charred pit-coal, a product more precious than the philosopher's stone; unless, indeed, we could imagine that, under so specious an appellation, the Rosycrusian experimenters really meant nothing more than '*metallum martis*,' the iron and steel of modern times." "The names of Dudley, Ravenson, Sturtevant, Wildman, and others, stand on record, soon after the interregnum, as speculators in the wide field of coke-iron working; and the number of patents which they obtained, the money they spent, and the mortification or ruin they severally experienced, collectively tend to prove that we are much indebted to them for having cleared the ground to such an extent."*

Various causes have at different times tended to influence the coal trade since the use of the commodity became general; but notwithstanding the competition of the places afterwards mentioned, as well as that of numerous inland collieries, the increase of the trade at its most ancient northern seat may be

* Cab. Cyclop. Manufactures in Metal, vol. i. p. 31.

said to have been, with some exceptions, progressive. To instance a single period: in 1800 the entire vend from the Tyne was 685,280 Newcastle chaldrons, and in 1826 it was 844,965 chaldrons; there was, however, a falling off in the next two years, the aggregate vend in 1828 having been 785,407 chaldrons. In 1830 the aggregate capital employed by the coal owners on the river Tyne was estimated at about a million and a half, exclusive of craft on the river.

The early history of the coal trade on the Durham side of the river Tyne, is so completely identified with that on the Northumberland side, both parties loading at Newcastle, that it is impossible to note the earliest progress of the Wear collieries in reference to the navigation of the last-named water. Surtees* supposes it to have been towards the latter end of the reign of Elizabeth, or in that of James, that the coal trade began to find its way into the port of Sunderland, which, in consequence, gradually rose into importance; whilst Hartlepool, the ancient port of the palatinate of Durham, dwindled in an inverse proportion into a mere fishing town. The burgesses of Sunderland, anciently known as "Weremouth," were incorporated by Morton, Bishop of Durham, in 1634: the export articles specified in the charter were, "sea-coals, grindstones, rubstones, and whetstones." During the civil wars, in consequence of Newcastle being stoutly defended for the King, the collieries on the Wear and the port of Sunderland became objects of vital importance; and it seems that the latter, in 1642, received a garrison for the Parliament.

* Hist. Durham, vol. i. p. 256.

About the middle of the seventeenth century (1654), we find the "Port of Sunderland by the Sea" mentioned, as beginning to be of importance; since that period, its commercial prosperity has gone on increasing, and it has long shared with Newcastle the advantages of the coal trade. It may be mentioned that the highest price ever obtained in the market, is for the best coal from the Wear. In 1800, the quantity of coals sent from the port of Sunderland, including the coastwise and foreign transit, was 303,459 chaldrons: in 1828, it had reached 532,508, the whole exportation during the 28 years having been something short of 12,000,000 chaldrons. About the time last mentioned, there were nine or ten large collieries on the Wear, in connection with which, capital to the amount of £600,000 to £700,000 is stated to have been sunk: about 700 colliers were employed; and in 1807, 7,518 ships, together of 102,454 tonnage, cleared with coals from the port of Sunderland. Coals raised from the Wear collieries, as well as from those upon the Tyne, are put into waggons at the pits' mouth, from whence they are conveyed, sometimes a distance of ten miles, to the staithes or spouts, and are either put directly into ships from the staiths, or placed in tubs to be conveyed thereto, or in bulk, in keels, to be cast on board by manual labour. And, as the Custom-house and other dues are collected upon the Newcastle chaldron, a Commission issued, 1 Geo. IV., for "the admeasuring and marking all and every the keels, pan-keels, and pan-boats and other boats, and wains and carts, used or in any time thereafter to be used for the carriage of coals for the port of Newcastle-upon-Tyne, and Sunderland upon the river Wear,

Cullercoates, Seaton Sluice, Blythnook, and all other places within the counties of Northumberland and Durham, and all and every the members, havens, rivers, creeks, and places whatsoever to the counties aforesaid belonging."

Not only has the port of Sunderland for many years shared with Newcastle the advantages and regulations of the northern coal trade, but Stockton, also, since about 1820, has established a sort of rivalry in this important traffic. The great coal owners on the Tyne and Wear appear to make common cause, especially in agreements as to the vend, &c. from which those on the Tees are excluded, apparently as being unwelcome interlopers in the field of business. There are about twelve collieries, which send their produce mostly by rail-roads—in one instance for the distance of twenty-five miles to the Tees, the water of which, however, not being sufficiently deep at Stockton to allow of the lading of large ships, the trade to London is less pushed (in 1830 it was upwards of 1,200 Newcastle chaldrons), than it is to the outports—vessels of 200 tons readily running up the smaller rivers. Some of the coal is of excellent quality, little inferior to the better sorts of the Tyne or Wear, especially the Old Etherley Wallsend: it is, however, tender, and therefore cannot be sent to market so large as some of the prime sorts whose name it bears, and which in this, as in some other cases, is arbitrarily affixed, because, as a Stockton coal merchant explained before the Committee of the House of Commons, the London purchasers "hardly consider they are coals unless they bear that name."

CHAPTER XVII.

VARIETIES OF COAL.

Composition of Coal—Gradations of Fossil Character —Mineral Arrangement—Brown Coal—Black Coal—Glance Coal—Sub-species of each kind—Varieties in the Trade—Difficult to identify several sorts—Qualities of Coal—English, Welsh, and Scotch Coals—Evolution of unconsumed matters during combustion—Burning of Smoke—Stone Coal.

IN the earlier Chapters of this Volume, we have entered somewhat at length into the natural history, fossil relations, and geological position of coal; having subsequently described the operations connected with raising it from the mine, we now come to notice those varieties which have been described by Mineralogists, and also to advert to the different qualities of this important fuel recognised in the market, as well as by the general consumer. "It has been customary," says Dr. Mac Culloch, "to regard coal as a combination of carbon and bitumen; but as the latter is itself composed of carbon and hydrogen, it is more accordant to nature, to regard coal as a bitumen, varying in its proportion of carbon, from the fattest

Newcastle coal to the driest blind coal that burns without flame or smoke." If this composition be assumed, we have, as congeners of the different kinds of coal,—at the lowest or descending extremity of an imaginary scale, and in contact with anthracite, the non-combustible plumbago or graphite, or, as it is commonly called, black-lead; and at the upper, or ascending extremity, cannel coal, jet, and black amber, approximating to those highly inflammable substances, common bitumen, asphaltum, and the fluids naphtha and petroleum. Another form of arrangement—and one, perhaps, neither less natural, nor less in accordance with the matter of the foregoing pages, would result from the construction of a scale, representative of the different changes ligneous substance undergoes in its transmutation from a recent vegetable state to its ultimate change, by a process of mineralising causes, into perfect coal: something like this has been attempted in previous chapters on the natural history of coal.

Jameson, in his arrangement of minerals, "according to the Natural History method," distributes the coal genus into three species, viz. Brown Coal, Black Coal, and Glance Coal: these are again divided into sub-species.

I. *Brown Coal.* 1. Bituminous wood, or fibrous brown coal: the fracture is woody, of a dark brown colour; it burns with a clear flame and bituminous smell. This is the fossil found at Bovey, as already noticed: it likewise occurs, differing somewhat in condition, in many other parts of Europe. 2. Earth-coal, or earthy brown coal, which occurs massive, of a brownish or pitch black: it sometimes passes into bituminous wood, with which it is found, and from

which it differs principally in its state of aggregation, being commonly of a loose consistency. 3. Alum-earth, which flames when exposed to heat. It is said to occur in vast beds in alluvial land: it has also been remarked, that where beds of brown coal have a covering of clay, they afford good fuel; but, when the cover is sand, the subjacent coal is alum-earth. It is not found in this country, nor much used for fuel. 4. Common, or conchoidal brown coal, which is found at Bovey; it burns with a weak blue-coloured flame, and emits a smell like that of burning bituminous wood. It is distinguished by a high degree of lustre, and conchoidal fracture: we find in it iron-pyrites, honeystone, amber, and a substance resembling retinite. 5. Moor coal, or trapezoidal brown coal: it is the most frangible species of coal; its fragments approaching to cubical. It is not found in this country—though elsewhere it is the most abundant kind of brown coal.

II. *Black Coal.* 1. Slate coal. To this species is commonly referred the rich caking coal of Newcastle, and of the other reputed coal districts. Mr. Hutton, however, considers the slate coal of the Tyne collieries, to consist of the true caking coal of the district arranged in thin alternate layers, with the cannel, parrot, or splint coal, and deriving from this arrangement, its slaty structure. Slate coal is described by Jameson, as being in colour intermediate between velvet-black and a dark greyish-black. Sometimes it presents a pavonine or peacock-tail colouring*, sometimes a columbine tarnish. It oc-

* Splendid specimens of iridescent coal occur in the anthracite of Pennsylvania: sometimes the pieces are of a deep rich blue; generally, however, the colours resemble those with which our own coals are frequently tinged; but the conchoidal fracture and lustrous appearance of the pieces combine

curs massive, and in ovoidal and columnar concretions. It is shining or glistening, and the lustre is resinous. The principal fracture is nearly straight, and generally thick slaty; the cross fracture is imperfect and flat conchoidal, and sometimes even or uneven. The fragments are sometimes slaty, sometimes trapezoidal, or indeterminate angular. It is harder than gypsum, but not so hard as calcareous spar: the lustre is heightened in the streak, brittle, inclining to sectile, and easily frangible. According to Dr. Thomson, this variety of coal contains of constituent matters, the following proportions :—carbon 65.28; hydrogen 4.18; azote 15.96; oxygen 9.58= 100.00. It passes sometimes into cannel and foliated coal. 2. Cannel coal, in colour, and several other particulars, resembles the last named subspecies, has a large and flat conchoidal fracture; it is so solid, and when pure, capable of receiving so good a polish, that snuff boxes and various toys may be made out of it in the manner of jet; in Yorkshire it is called branch coal,* and is often sought after by

to render them far superior to those from the mines of our own country as matters of ornament. In the masses which occur in various collieries of Great Britain, the colours are more diffusely distributed, and although sometimes very deep, they are rarely shining. In Staffordshire, this beautiful variety is called peau-coal; *peau* being the provincial appellation of a peacock. The cause of the colours is said by some to be due to the pecolation of acidulous and ferruginous waters; by others to the action of certain gases. The likeliest cause seems to be, the presence and oxidization of iron. Heat appears likewise to have had to do with producing the colours: the writer has picked up from the old burnt rubbish hills about Newcastle, specimens of half-consumed coal, exhibiting a very strong degree of iridescence. The tints, although appearing to pervade the substance of the coal, and really accompanying its free cleavage to an indefinite extent, consist, nevertheless, of an extremely fine film, induced superficially on the component laminæ of the mass, and may be easily scraped off with a penknife.

* Branch is a provincial term applied to the above, and other descriptions of coal, when the layers appear to shoot through or traverse the main body of the seam, from which they differ in quality, being generally more

turners: it is, however, commonly used as fuel, or distilled in the production of gas, being, although often of a dull aspect, yet of a highly inflammable and bituminous quality. According to the late Bishop of Llandaff (Dr. Watson), its common name is derived from the word *candle*, because in some places, especially in Lancashire, the poor formerly used it in the place of oil or tallow for lights. It occurs near Whitehaven, in Cumberland; Wigan, in Lancashire; Brosely, in Shropshire; near Sheffield, in Yorkshire; and also at several places in Scotland, where it is named *parrot coal*, probably on account of its flying about, and the crackling noise it makes when burning. 3. Foliated coal, occasionally occurs with the last named variety, either massive or in lamellar concretions; it is of a splendent resinous lustre, softer than cannel coal, and readily disintegrates by the action of the weather, and, when intermixed with iron-pyrites, will sometimes take fire, in consequence of the decomposition of the metallic ingredient.* Jameson mentions, 4. Coarse coal, composed of granular concretions aggregated together, but not common in Great Britain: also soot-coal, of an uneven earthy fracture, and dull, or sometimes semi-metallic lustre —it is found in Scotland.†

inflammable. One sort of coal, locally called branch about Sheffield, and much used in houses, is of a stone-like appearance, very hard and ponderous, but so highly inflammable, that a large piece laid upon the fire begins in a minute or two to crack, fly about in shivers, and inflame: it consumes rapidly away, if stirred, leaving few cokes but a large amount of earthy residuum. The slaty, cannel coal of Ayrshire, yields earthy parts, amounting to one-half of the whole mass.

* This spontaneous combustion has sometimes taken place, when the material has been put on board ship, and caused serious accidents.

† Annals of Philosophy, vol. xiv. p. 82. In his paper of the Composition of Pit Coal here referred to, Dr. Thomson only distinguishes four species, namely,—I. Caking Coal; II. Splint, or light burn hard coal; III. Cherry, or soft coal; IV. Cannel Coal.

III. *Glance Coal.* 1. Pitch coal, of a velvet-black colour; it is found in plates; sometimes in the shape of branches, with a regular woody internal structure: it burns with a greenish flame. It occurs in secondary trap rocks in the Isle of Skye; and in a variety of situations on the Continent, where it is used for fuel, either in its natural state, or when converted into coke. It is of a still more compact, jet-like nature than the branch coal abovementioned; and, according to a report published in the "Journal des Mines," twelve hundred men were employed in the district of Oude, in France, in fabricating with the pitch-coal of that neighbourhood, rosaries, buttons, ear-rings, necklaces, bracelets, snuff-boxes, drinking vessels, &c. One thousand cwt. are yearly expended for this purpose; and to Spain alone, the value of 18,000 livres is sold. In Prussia, the amber-diggers, who name it black amber, cut it into various ornamental articles: it was formerly known by the name of Gagat or Jet, from the river Gaga, or the city Gagus, in Lesser Asia, where it was dug.* 2. Glance

* We have already mentioned, that the highly compact species of lignite, denominated jet, has been deemed by some writers bituminous vegetable matter in a state of change between peat and mineral coal. The learned Wallerius, and the celebrated Fourcroy, have contented themselves with considering jet merely as asphaltum; whilst others have simply described it as coal. Mr. Hatchet considers jet to be neither asphaltum nor coal, but an intermediate substance, which may be regarded as the first gradation from the simple bitumen, into those which are compound. Parkinson considers amber and jet as identical. In proof of this opinion, he quotes the following relation from the learned Dalecamp, in his Annotations on the Natural History of Pliny:—"I have," says this author, "a piece of jet which, beyond all doubt, has been digested for many ages in the bowels of the earth. It was dug out of the quarries near Narbonne; one half of it is black, and the other yellow, resembling amber." It is plain, that writers sometimes comprehend under the terms jet and amber, substances of decidedly different origin: what is commonly taken for each, may have been found combined as described by Dalecamp,—but, that there is pure amber which has had a liquid origin, and fine jet with a decidedly woody grain, is undeniable. The

coal. This sub-species includes four varieties:—Conchoidal glance-coal, Slaty glance-coal, Columnar glance-coal, and Fibrous coal. The first of these kinds is the compact anthracite of Haüy. Its colour is iron-black, inclining to brown: the surface sometimes exhibits a tempered-steel-coloured tarnish; and thin pieces ring like metal. It burns without flame or smell, and leaves a white coloured ash. It is found in Staffordshire, and in Scotland. The slaty glance-coal resembles the last in colour, except where bordering on the graphite, when it inclines to a steel-grey, or plumbaginous aspect. "According to Dolomieu, when reduced to powder, and heated in a crucible, it does not give any sulphureous or bituminous odour, and on distillation, it affords neither sulphur nor bitumen. By exposure to a considerable heat, it burns without flame, and at length is consumed, leaving a greater or lesser portion of ash, according to its purity." This is the anthracite so abundant in the United States; the *culm** of our Welsh collieries, and the *blind coal* of Kilkenny. It occurs also with the preceding kind in Staffordshire, and several parts of Scotland. The columnar glance-coal resembles

ligneous origin of jet can scarcely be said to be disputable. In the Cabinet of Mineralogy in Languedoc, M. Chaptel preserved several pieces of wood, whose external part is in the state of jet, so that in these, the transition from the vegetable to the mineral state may be distinctly observed. At Montpelier have been dug up, several cart loads of trees converted into jet, with their original forms so perfectly preserved, that the species of trees thus bituminized can often be determined. A specimen of jet from Vochery can be distinctly recognised, as retaining the texture of the walnut tree; and the texture of the beech can be traced in the jet from Bosrup, in Scania. The most singular instances, however, are those of a wooden pail, and of a wooden shovel, which M. Chaptal, whose authority is undoubted, affirms to have been converted into pure jet.

* This is a brittle crumbling anthracite—the *Bitumen Oxygenatus* of the Linnæan system. The term, however, is frequently applied in this country to any small refuse coal of bad quality which may be brought to market.

the last in colour: it occurs massive, disseminated, and also in prismatic concretions, from which its name is derived: like the rest of the species, it burns without flame or smoke. We are informed by Professor Jameson, that it forms a bed several feet thick, in the coal-field of Sanquhar, in Dumfries-shire; at Saltcoats, in Ayrshire, it occurs not only in beds, along with green-stone, slate-clay, clay-ironstone, and bituminous slate, in the coal formation of that district, but also imbedded in the green-stone; about four miles from New Cumnock, also in Ayrshire, there is a bed of columnar glance-coal, from three to six feet thick, in which the columns are arranged in rows like basalt, and which is intermixed with compact, scaly, and columnar graphite. Both the graphite and the columnar glance-coal are contained in the coal formation; and in some places, contemporaneous masses of green-stone are imbedded in the coal.* Fibrous-coal, or mineral charcoal, occurs imbedded, or in thin layers, in black coal, sometimes inclosed in pitchstone. It is met with in the different coal-fields of Great Britain, and in similar situations on the continent of Europe: "its fibrous concretions and silky lustre distinguish it from all the other kinds of coal; it is not certain that this mineral is wood mineralized—several of the varieties may be original carbonaceous matter crystalized in fibrous concretions."

Besides the foregoing distribution, founded upon the external character of the different species, and adapted for the purposes of popular classification, a great variety of appellations are current in the trade, as indicative of the quality of the coals, and in respect of which, prices are regulated in the market. These

* Jameson's Mineralogical Description of Dumfries-shire.

terms are generally taken from the pits or places whence the coals are brought ; and in reference to the best and worst kinds, and even to several between these extremes, they are perhaps sufficiently distinctive to prevent practised dealers from being imposed upon, however little they may assist, or however much they may confound purchasers in general.

About seventy denominations of coal are said to be imported into London, of which, between forty and fifty are sent from Newcastle. Amidst so many varieties, to say nothing of new sorts, or old sorts with new names which are constantly introduced, the distinctions must often be purely arbitrary; not one person in a thousand being, in fact, able to affirm or deny that the coals of intermediate quality are of the sort implied by the denomination. The coal meters themselves, when examined on this point before the Parliamentary Committees in 1830, admitted that they could not accurately distinguish between the different qualities, though they could tell best coals from such as were inferior, and also discriminate between two or three different sorts.

Where so much uncertainty exists, even in the judgment of individuals the most extensively conversant with the trade, how wide a door must be opened for fraud and roguery! As, however, no suspicion ever attaches to the parties who first ship the coals from the pits, the London merchant purchases with confidence, the ship's certificate always accrediting the quality*: but after the coals have once been re-

* This was not always the case in the earlier eras of the trade. In 1618, information was laid in the Star Chamber against several hostemen and skippers of Newcastle-upon-Tyne, for adulterating coals. And again, in

moved from the vessel to the warehouse, neither official vigilance,* nor personal interest, could always prevent those tricks of *manufacturing*, or substitution, by which the price is enhanced by screening, mixing various sorts, and affixing to the inferior commodity as reputable a name as it will bear.

Coals may be considered as absolutely good or bad, when they are free from, or much mixed with, heterogenous substances; and relatively good or bad as they happen to be more or less adapted for particular purposes. The "Wallsend,"† or best Newcastle coal kindles easily; in burning, it cakes or runs together, but not to such a hard solid mass as some other sorts, emitting, at the same time, a great deal of heat, as well as of smoke and flame; it leaves a small quantity of dark-coloured residuum or ashes. The sorts of coals usually denominated in the London market "Tanfield," commonly burn slowly, cake very hard, and afford a strong and long continued heat: the other varieties are of an intermediate character. The Whitehaven coal is said to approach very nearly to

1631, an action was entered in the same court, by Heath the Attorney General, against the hostemen of Newcastle, for unlawfully mixing 40,000 chaldrons of coals.

* In order to secure, as far as possible, that one sort of coals be not delivered for another sort named, the late statute provides, "that if any seller or dealer in coals shall knowingly sell one sort of coals for and as a sort which they really are not, within the distance of twenty-five miles from the General Post Office, every such offender shall forfeit ten pounds per ton, for all coals so sold, and so in proportion for any smaller quantity."

† Wallsend, so called, as being the spot where the celebrated wall of Severus terminated on the northern bank of the Tyne, a few miles below Newcastle, has, in modern times, been chiefly known as the site of a colliery yielding the most valuable description of coal. So important, indeed, is the appellation in the market, that although the high main seam which afforded the original coal has long been worked out, the designation has not only continued to be applied to some one other sort, as the best—but to several sorts which the dealers wish to recommend.

the nature of the Newcastle coal. In the better kinds from both places, the former has been found to possess one per cent. less of carbon, and one per cent. less of bitumen. The Cumberland coal much seldomer contains any intermixture, than is found to be the case with many sorts from Northumberland. The Whitehaven coal burns at first with a clear flame, and for a long time, but at last cakes. The Wigan coal burns quicker, and cakes less. The Swansea coal burns slowly, and cakes. The Leitrim coal cakes only slightly. Caking coal gives out a great quantity of heat, and with attention, burns a long time; consequently, where it can be procured at a reasonable price, it is commonly preferred.*

For the steam-engine furnaces in Cornwall, those coals are preferred which, in a brisker fire, clinker most; none but Welsh coals have hitherto been used. According to Mr. Galloway,† however, the Swansea coal is equal in its effect. Llanelly coal too, has been strongly recommended, and found satisfactory. Brindoney coal has also been spoken of highly, and appears to the celebrated engineer abovenamed, to possess decided advantages over the coal commonly used in the furnaces of the steam-engines.

Mr. F. Forster, in a series of interesting observations on the South Welsh coal basin, published in the First Part of the Transactions of the Natural History Society of Northumberland, already adverted to in previous chapters, gives the following Table, as exhibiting the results of an examination of several varieties of Welsh coal:—

* Tredgold.

† On Cornish Steam Engines. Repertory of Patent Inventions. August, 1833.

SEAMS IN A LINE OF SECTION FROM NORTH TO SOUTH.	Volatile matter, per cent.	Carbon per cent.	Incombustible earthy residuum, per cent. leaving in combustion.
Stone Coal.			
Seam on Mynydd Bach Llanedi,..................	8.65	89.85	Pale yellow ashes,......1.5
Free Burning Coal.			
Clyngwernon seam, ...	14.	79.0	Heavy reddish ashes,....7.0
Penprys seam, ...	14.5	82.0	White ashes, ...3.5
Bituminous Coal.			
Gelle Gile seam,..........	16.8	80.6	Red ashes, ...2.6
Llwchor colliery 5 feet seam,	19.	78.5	2.5
Globrâisc seam, Adair colliery	27.5	72.2	Yellow ashes,..........2.3
SEAMS IN DIFFERENT PARTS OF THE COAL BASIN.			
Cox's stone coal Cwm Zurch,	7.5	91.5	Yellow ashes,..........1.0
Pool coal W. of Llanelly, ..	19.8	77.8	Reddish ashes, ...2.4
Bushy seam, Llanelly, ...	15.9	81.6	Do. do. 2.5
Great seam at Merthyr,....	13.4	85.6	White ashes, ...1.0

A glance at the foregoing Table will show how various are the proportions of the matters entering into the composition of coal from the same basin: one description of stone-coal containing 8½ parts out of one hundred, of volatile matter, while one of the bituminous varieties yields upwards of 27 parts; and while one sort leaves, on combustion, only 1 per cent. of ashes, another leaves 7 per cent. The great seam at Merthyr, is that from which the larger proportion of the coke for the blast furnaces is procured; it is coked in heaps in the open air, and produces a close-grained coke of a silvery lustre, and very free from sulphur.

The Scotch coals are mostly what are termed *open-burning,* in opposition to *caking* coals. According to Mr. M'Culloch, they cannot last so long as those from Newcastle; yield less heat: do not run together in burning, and usually leave a considerable quantity of white ashes; in these respects resembling several of the Yorkshire sorts. They make, however, a very plea-

sant cheerful fire; and for most household purposes, the best fire is said to be made of a mixture of the last mentioned, and the Wallsend coals.

Some of the inferior descriptions of coal contain so large a proportion of earthy or other impure admixture, that they not only burn badly, but yield an immense quantity of dull ashes: several of these sorts indeed are sufficiently inflammable, and, for a while, hot enough; for bituminous shale itself will flame readily, and, while red, emit a good degree of heat; but it presently dies, and, when mixed with better fuel, as not uncommonly happens, a slab of it forms a most annoying obstruction to the burning of an ordinary fire; as it frequently costs nearly the clearing of the grate to eject the stubborn intruder.* When, as is the case with the coal from some districts, it contains a portion of lime, the ashes are not only abundant, but so light that they fly about in every direction. The presence of lime with a trace of magnesia, is often displayed in those whitish lamina of a crystallised structure, which are distributed through the coal in the insterstices of its longitudinal fracture, as the presence of iron pyrites is demonstrated by the great weight and brassy appearance of some kinds of coals. This metallic deterioration,

* Williams mentions a description of bituminous shale or ironstone, or, as he calls it, when in lumps, "glossy greasy blaes, which have such a quantity of the natural oil as to make them flame a little in the fire; and there is in some places a considerable quantity of the hard stratified blaes, which will not only flame in a fire, but some of it will actually burn when fire is set to it, though it will not consume. There is a species of pretty hard stratified blaes at Pitfirran, in Fifeshire, which burns so well, that if a small fire is once kindled at one corner of a hillock, it will burn throughout; but it is no less in bulk after than before it was burnt, nor does it produce any ashes. This blae is of a pretty good black colour before it is burnt, but the fire turns it to a pale red, in which it is so far from consuming, that it acquires a considerable degree of hardness in the fire, which makes it pretty good stuff for roads."

however, although highly objectionable on other accounts, is less troublesome in the burning than that of the lighter matter; for while it falls in a ponderous reddish-coloured ash, and thus, in common with earth and lime, tends to choke the fire, it does not produce so much dust to fly about a room.

The kinds or differences of coal mainly depend, as already shewn, upon the comparative proportions of carbon and hydrogen entering into their composition, and of earthy impurities totally incombustible. While some species of coal contain nearly a third of their weight of hydrogen, others have not a fiftieth. The former kinds are flaming coal, so pleasing in domestic fires, and especially fit for the production of gas for purposes of illumination: in the manufacture of the latter commodity, the cannel coal of Lancashire, and the branch coal of Yorkshire, are much used. When they are burned where a sufficiency of oxygen cannot pass through or enter above the fire, to combine with and consume the hydrogen as fast as it rises, a dense smoke is given out, consisting of hydrogen and carbon combined in the proportions which form a pitchy substance. The smoke given off during the combustion of flaming coal in most large towns, especially the prodigious volumes of it emitted from the chimneys of manufactories, form a serious annoyance in many situations; though it does not appear that any directly insalubrious effects can be charged upon even so fuliginous an atmosphere as that of London; there have, however, been various projects for abating the nuisance on a large scale.*

* The subject was discussed by Evelyn in a work entitled "Fumifugium"; and by a person of the name of Frend, who in 1819 took up the enquiry, "Is it possible to free the atmosphere of London, in a considerable degree, from the smoke and deleterious vapours with which it is hourly loaded?"

That it is possible to consume the smoke of steam-engine and other similar furnaces, is an undoubted fact, as it is constantly done in some places with complete success—and where not done, it may be legally presented as a nuisance in a court of justice; still, as the process requires rather more expensive arrangements, and a little more care than ordinary, and as the saving in fuel is probably in no case correspondent, the inventions already made known for the purpose are by no means generally adopted.

A very striking contrast to the murky exterior of some of the large towns in this country, is presented by the appearance of the city of Philadelphia, over which, notwithstanding its thousands of coal fires constantly kept up, there is no smoke. The inhabitants mostly burn the anthracite*, or stone-coal,—a substance resembling the Welsh culm, the Kilkenny coal, and the blind or deaf coal of Scotland. These

One project was this: instead of allowing the smoke to issue by thousands of chimneys all over the metropolis, that it should be conveyed downward into subterranean conduits, and by them be carried to large vents outside the town, and there dispersed.

* A writer in the Journal of the Academy of Natural Sciences at Philadelphia, gives the following as the result of a careful analysis of the anthracite of Lehigh:—

Carbon			90.1
Water			6.6
Residue by incineration of a dirty white colour	3.3, consisting of	Silex	1.2
		Alumine	1.1
		Oxides of iron & manganese	0.2
		Loss	0.8
			100.0

In a specimen from Rhode Island, Connecticut, the results were:—Carbon, 90.03; water, 4.90; and the residue by incineration, which was of a light brick red, 5.07,—consisting of silex 2.14, oxides of iron and manganese 2.50, loss 0.43 = 100.00. The quantity of water contained in anthracite is noticed as remarkable in this analysis.

coals are difficult to kindle, which may have given rise to their name; but when once thoroughly ignited, they burn for a long time: they make a hot glowing fire, like charcoal, without either flame or smoke; but owing to their commonly emitting noxious vapours, they cannot be pleasantly used in dwelling-houses in this country, though they are in considerable demand among maltsters, dyers, &c.; more especially for the furnaces of steam-engines and breweries in those situations where smoke is a severe nuisance.

CHAPTER XVIII.

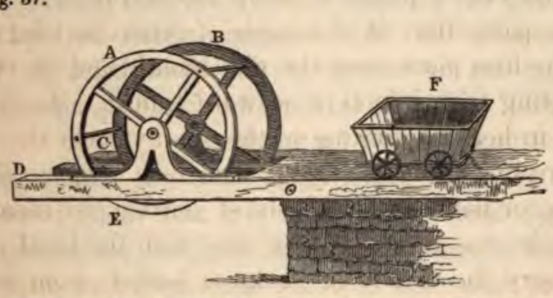
CONVEYANCE OF COAL.

Earliest Methods of Conveying Coals—On the backs of Beasts—In Carts and Waggons—Tippler—Staiths—Drop and Spout—Origin of Rail Roads—Waggons—Self-acting Railway—Keels, or Coal Barges—Method of Navigating Keels—Hostemen, or Fitters—Maritime and River Trade—Coal Trade the Nursery of Seamen—Impressment.

THIS is a topic which might have been treated of with propriety in a preceding Chapter; but as it contains too many interesting details to justify its dismissal with a merely general or brief notice, it will not be out of place to group under the above title, some particulars of the mode of removing the coals, in the first place from the pits' mouth, and afterwards effecting their inland or seaward transit. To lay the coal in heaps according to the quality, near the place where it was obtained, and from such heaps to fill the carts, or panniers of beasts of burden, by means of shovels, was the ancient method with the local vend: to carry the article in sacks or baskets from the repository on board ship, would be the obvious suggestion of inexperience in reference to sea-going coal.

In some places, as about Sheffield, carts are mostly employed in carrying the supply of coals from the pits to the town, where, as the daily consumption is enormous, the number of these vehicles on a road between the town and the pits from two to four miles off on the east side, appears surprising to a stranger. At many of the collieries in the neighbourhood adverted to, the carts are filled "from the heap," as it is termed, and the amount in corves estimated from the size of the cart, or more commonly it is taken over a platform machine and exactly weighed, the quantity being reckoned, either as so many corves according to a standard understood between the parties, or paid for as per the actual weight. As it is well known that coal deteriorates and crumbles by exposure to the weather for any length of time, purchasers always prefer those descriptions that are fresh drawn from the mine to others that may be filled from the "old heap"; when coal is sold under the former circumstances—which will always be the case where the demand is equal to the supply, it is shot immediately from the little waggon or corfe into the cart, by means of an ingenious contrivance called a *tippler*,

Fig. 37.



(*fig.* 37.) and which from its use, at Leeds gives designation to the measure of the waggon which it is

employed to empty; hence, the price of coals is said to be so much *per* tippler, instead of so much per corf or cwt.

A B (*fig.* 37.) represent two cast-iron wheels of about three feet in diameter, and firmly connected from the inner side of their rims by wrought-iron bars: at right angles with these bars, and coincident with the diameter of the wheels, are fixed inside, two pieces C, forming the portion of a railway corresponding to the length and width of the corfe to be emptied. Thus constructed, the machine is poised on brackets, by means of central pivots outside the wheels, near the extremity of projecting timbers, one of which is seen at D; the whole being so arranged as that the pieces between the wheels shall fall (when the tippler is at rest) exactly level with the platform adjoining the pit-hill, or the termination of a short rail-road laid therefrom, while there shall be just sufficient room below to admit the introduction of a cart. With this arrangement, there is nothing to be done on the part of the carter but to back his vehicle under the machine at E, and then, on running the corfe F into the tippler, the latter turns partly round, shooting the contents of the corfe into the cart at E: afterwards, the little waggon, which is kept from falling out by means of the cross bars, is, when emptied, easily, by turning the frame up again, withdrawn to make way for another.

It is by a contrivance having a similar object, though dissimilar in principle, and vastly more ponderous in construction, that waggons, containing from two to three tons of coals, are emptied at once from the *staiths* into the ships on the rivers in the north of England. No person can sail down the Tyne from

Newcastle bridge to North and South Shields—a distance of ten miles, without being exceedingly struck with the appearance of these immense structures of timber, erected at short distances from each other, on both sides of the river.* Places for the convenience of lading coals from the bankside into the keels, were no doubt constructed at a very early period; and in the chartulary of Tynemouth Monastery, "staithes" are incidentally mentioned so early as A.D. 1338; these were, probably, however, nothing more than small wharfs or platforms, as in a grant, made by the Bishop of Durham in 1575, the lessee of certain mines is to have "sufficient way-leave† to the water of Tyne, where he was to have *a staith to lay the coals on.*" The word staith is plainly derived from the Anglo-Saxon staþe, *ripa, littus, statio navum.* At Hithe, in Kent, the landing place is called the Stade.

"Where the pits," says the old Encyclopædia Edinburg. *voce* Coalries, "are situated at some considerable distance from the harbour, it becomes neces-

* These staiths have often been the subjects of litigation and complaint, as well as of rioting, especially on the part of the keelmen, on account of their projecting so far into and over the river as to impede the navigation.

† In every period of the history of coal mining in the North, these "way-leaves" have formed an important item of expenditure, or covenant. "*Sufficiens chiminum*" occurs in the latter sense in a lease to the Prior of Durham in 1354. *Chiminum* is a term often met with in grants of property to monasteries, and implies a right of road to or through the lands appropriated. Mine proprietors or adventurers, who possess collieries which do not happen to border immediately on a navigable river or the sea-coast, must necessarily procure the privilege of wayleave through the estates of proprietors which may intervene between the mines and the place of shipment. As this is altogether a matter of bargain between the parties, it must be obvious that exorbitant rents will sometimes be demanded. Lord Keeper Guildford tells us, in his Observations on the Collieries, &c. about Newcastle, written in 1676, that "another thing remarkable is their way-leaves; for when men have pieces of ground between the colliery and the river, they sell leave to lead coals over their ground; and so dear, that the owner of a rood of ground will expect £20 per annum for this leave."—*North's Life of Guildford.*

sary to have a store-house near the shipping place, where the coals may be lodged until the lighters or ships are ready to take them in. The waggon-way should be made into the store-house, at such a height from the ground, as to permit the coals to run from the waggons down a spout into the vessels; or else to fall down into the store-house as occasion may require. This kind of store-house is well adapted to dispatch, and saving expence; for a waggon load of coals may be delivered either into the store-house or vessel instantly, with very little trouble; and if the coals were exposed to the effects of the sun and rain, they would be greatly injured in their quality, but being lodged under cover of the store-house, they are preserved."* When the waggons are emptied into a keel or vessel by a spout, it is called a trunk staith: at Whitehaven, they are called steers. "When a waggon lets fall its contents down one of these spouts, the noise at a distance," says Brand, "very much resembles a clap of thunder. These waggons, after being emptied, are brought round into the road or waggon-way by a turn-frame, and each is drawn back by a single horse."† The store-houses mentioned above are very useful, especially where coals of a tender description are not disposed of immediately on

* The covered part of the magazine placed parallel to the quay at Whitehaven, is stated, in the Life of Dr. Brownrigg, to be in length 115 yards; in breadth, 19 yards; and in depth below the waggon-way, 8 yards. It consists of 17,480 cubic yards, and, at 3⅓ cubic yards to the waggon, will contain 5244 waggons of coals. The uncovered part is, at the south end, 40 yards long, 28 yards broad, and 7 yards deep. It will consequently contain 2352 waggons.

† The waggons from the pits to the quay at Whitehaven are managed in a similar manner. The waggon-way on which the coals are carried into the magazine, and to the different spouts, has a descent, from the entrance to where the waggons pass out, of about one-sixth of an inch in each yard. The covered gallery along which the waggons are brought from the Howgill Colliery, is elevated about 37 feet above the level of the quay.

their being drawn from the pit: the latter, however, is generally the case at Newcastle, nor does there at present exist more than one or two such store-houses on the banks of the Tyne. The annexed is an outline representation of the staith, by means of which coals are shipped from the collieries about Wallsend.

Fig. 38.

A (*fig.* 38.) is the platform upon which the railroad terminates: it is supported by upright and cross timbers over the river. At the extremity of the platform is a wooden shed B, across which passes a strong axle, having upon it four large pullies, two inside and two outside the shed. Upon the two former, wind the flat ropes C, attached to the stout lever D, which is composed of two beams, (appearing as one in profile), connected by transverse pieces, and working by bolt joints at E: upon the two latter, or outside pullies, wind on each side other flat ropes F, fastened

to long levers of timber as G. The weight H, which along with these levers is intended to counterpoise the waggon I, consists of a pile of cast-iron slabs. In the quiescent state of the machine, this weight is at the bottom of the frame, while the upper end of the lever D, stands nearly vertical within the open front of the shed,—a cradle hung at the end of it for the reception of the waggon, lying, at the same time, exactly level with the rail-road of the platform A. In this state, if a loaded waggon were moved into the cradle or slip, and the latch loosed, it would rapidly descend by a curved line from the platform to the ship—the machinery in the middle stage of the transit appearing as in the engraving. To counteract, however, the dangerously rapid descent of the load, the axle in the shed carries, in addition to the rope-rollers above described, a large wheel of wood, constricted by a brake, and turning in the outshot K, where the staithman manages it by means of a lever. Commonly, a man descends with the waggon, and upon reaching the deck of the vessel, strikes out the catch of the trap-door or loose bottom of the waggon, thus emptying the contents at once into the hold. The weight H then descends, the empty waggon and its attendant meanwhile being drawn up to the position first described. Spouts have already been mentioned; one of these conveniences usually occurs along with what is locally termed the drop, just described. In the figure alluded to, L indicates the position of the spout, and M the tackle connected with a board to regulate the descent of the matters passing down. Small or inferior coals are readily loaded by the spout, the waggon bottom being merely loosed over an opening of the platform, and its contents suf-

fered to run down directly into the vessel moored underneath.

In consequence of the intense interest which, within the last few years, has been excited in the public mind relative to railroads, and the accessibility of various publications in which the subject has been discussed, the reader will be prepared to hear that these vastly expensive and widely ramified lines of inland transit, had their origin in the railways laid down to facilitate the movement of the coal waggons between the above-mentioned staiths and the various collieries in the north. At what period these roads were first introduced, does not distinctly appear. Down to the year 1600, the mode of conveying coals from the pits to the river, seems to have been by carts, on the ordinary roads, and in some instances by "panniers" on horseback.* Half a century afterwards, we are told, "many thousand people are employed in this trade of coals: many live by conveying them in waggons and wains to the river Tyne."†

Soon after the last-mentioned period, we have unequivocal mention of railways, constructed, as the appellation would imply, of pieces of timber laid parallel upon wooden sleepers, and upon which, waggons with small trundle wheels were drawn along. An obvious improvement was to plate the rails with iron; and remains of this description may still be seen about Newcastle. The earliest satisfactory mention of iron rails refers to the year 1767, when six tons appear to have been cast at the great iron-works of Colebrook-Dale, Shropshire, and laid down by way of

* Treatise on Railroads, by Nicholas Wood. In this work will be found ample information, historical, practical, and theoretical.

† Gray's Chorographia.

experiment—but with what success does not appear. Mr. Curr claimed "the making and use of iron rail-roads," in 1776, as one of his "inventions," for working the Duke of Norfolk's collieries at Sheffield. The ingenious individual just named, formed his roads of light cast-iron edge-rails—and to him was probably due, if not absolute priority in the attempt to substitute iron for wood, yet the first successful application of metal for the purpose intended, by making a number of small waggons, and linking them together, so as to distribute the weight over a greater space, and thus to overcome a difficulty in the way of conducting the original heavy vehicles along the newly devised roads. It would be out of place here, to go into any details concerning the progressive improvements by means of which rail-roads have arrived at their present pre-eminent degree of perfection and utility, in connexion with the use of locomotive steam engines.

Lord Keeper Guildford, who was upon the northern circuit in 1676, thus describes the waggons and the waggon-ways:—"The manner of the carriage is by laying rails of timber from the colliery down to the river, exactly straight and parallel; and bulky carts* are made with rowlets, fitting these rails, whereby the carriage is so easy, that one horse will draw down four or five chaldron of coals, and is an immense benefit to the coal merchants." In situations where these roads were inclined, and particularly when plated with iron, no horse was required to draw the

* There was a tradition among the old people connected with the coal works, that the first waggon that was used for this purpose in the vicinity of Newcastle, was lined with tin, and filled with the liquor called punch. It is easy to conjecture that the unloading of such a waggon would prove a very grateful task to the thirsty workmen.—*Brand.*

waggons, as without such aid they ran along very readily, "and sometimes with such rapidity, that a piece of wood called a tiller, is obliged to be applied to one wheel, and pressed thereon by the weight of the attendant, who sits on it to retard the motion; by the friction of which the tiller, and sometimes the carriage, is set on fire." The wooden brake thus applied upon the wheel is called a convoy, and may still be seen constantly in use on the rail-roads about the collieries in the north. In some cases the waggons are of sheet iron; attached to these vehicles, and, indeed, generally also to the wooden ones now-a-days, is a convoy of a better construction, bearing upon two wheels; the waggon-man standing on a projecting part of the vehicle, and pressing upon a lever, as shewn in the annexed sketch (*fig.* 39.) It is not uncommon to see a horse yoked *behind* the loaded waggons in their descent; the animal by this means assisting to prevent their too rapid motion, and being also ready to draw the waggons back, after they have discharged their contents at the staithes.

Fig. 39.

The waggons are wider at the top than at the bottom, and when made to carry about fifty hundred weight of coals, measure as follows:—length at the top, 7 feet 9 inches; breadth at the top, 5 feet; length at the bottom, 5 feet; breath at the bottom, 2 feet 6 inches; perpendicular height, 4 feet 3 inches. These vehicles are usually made with a sort of trap-door at the bottom, which on being loosened lets the coals fall through without further trouble than the striking of a

Fig. 40.

catch—a contrivance which did not pertain to the original waggons. In many of the collieries, as well on the Tyne as elsewhere, where the situation is favourable, and the distance not too great, the coals are removed from the pit to the river or other place of loading, by means of what is called a self-acting railway, which is just so much inclined that one train of waggons when loaded, shall, by their descent, bring back to the pit's mouth those that have been emptied. To effect this, the two sets of waggons are attached to the opposite ends of a stout rope, which passes over a wheel, commonly placed in a horizontal position A (*fig.* 40.) at the top of the inclined plane, the velocity of the train being regulated by the contrivance just described. In some instances, this object is effected by means of a connection between the horizontal wheel and the machinery of the steam engine. At intervals of ten yards along the road, cast-iron wheels about the size of a man's hat, with a deep semicircular hollow in the face, are fixed for the rope to fall into as the waggons pass down—thus preventing the rope from being worn by trailing on the ground, and at the same time avoiding the friction which would be consequent upon leaving it so to trail: when there is any curve in the road, as sometimes

happens, the friction pullies in that part are set in a leaning position, with their hollows towards the convex side of the segment, so that as the weight of the trains tends to draw the rope into a right line, it is sustained and kept tight by the runners, though its direction deviate never so much from a straight course. It is not necessary in these self-acting roads, that there should be a double suit of rails all the way; it is sufficient that they be doubled at the middle of the line for about one hundred yards, in the manner shewn in the cut *(fig.* 40.*)*, to enable the waggons to pass each other as at B C, which, as the length of the rope never varies, they will, of course, always do at the same place.

At one of the collieries near Sheffield, the coals are conveyed from the pit to the canal, a distance of about a mile, in small waggons, each containing six cwt.; twenty-four of these waggons are placed upon a combined platform of three vehicles of four wheels each *(fig.* 41.*)*, which runs along a rail-road, self-

Fig. 41.

acting by means of a plane, as above described. On reaching the coal wharf, these waggons are transferred severally from the stage to a small rail-road, where, on account of their convenient size, they are easily managed. In this instance, the friction wheel A *(fig.* 40.*)* consists of three several peripheries on the same vertical shaft—the uppermost of metal,

eight feet in diameter, with a deep grove in its periphery for the passing of the rope; the next a wooden one, with a clip and brake to curb its velocity; and the undermost a cog-wheel of cast-iron connected with the pinion of a shaft belonging to a small independent steam-engine.

On the canals, and on several of our navigable rivers, coals are distributed for inland consumption by means of barges of different sizes.

On the Tyne, the coals used to be carried from the staiths to the ships, almost exclusively, in a sort of oval vessels, called keels, of which, considerable numbers are still employed in bringing down the produce of the collieries situate above Newcastle bridge (which the sea-going craft cannot pass,) to the ships lying about Shields, and which do not load at any of the staiths between those places. A keel is considered to contain by admeasurement, eight Newcastle chaldrons: the coals, when large, are generally piled in the vessel according to convenience; and when small, deep side-boards are added, within which the commodity is heaped up; but, in some cases, where the coal is tender, tubs are used to prevent the breakage as much as possible. These tubs are a sort of waggons without wheels, containing one Newcastle chaldron, or 53 cwt. each; eight of these being placed in a keel, go to the vessel, into which the tub is lifted by means of a crane, and when immediately over the hatchway, the trap-door is loosened, and the contents let down into the ship with as little injury as possible.

These keels, which are evidently built after an ancient model, and the method of managing them, present striking features in the navigation of the

river: the keelmen, too, are an exceedingly hardy and striking class of men, whose avocations under the designation of "kelers" are mentioned so early as 1378.* Their vessels were afterwards called "lightners," apparently modified for euphony's sake into the modern lighter. The chief person on board the keel, is called the skipper; an errand boy, or assistant, the P. D.; the cabin of the keel is called the huddock; and the great oar, which is used as a kind of rudder at the stern of the vessel, is the swape; the poles with which the keelmen push on their keels in shallow water, when it is inconvenient to use sails or ears, are called puys: the keels on the Wear are wholly managed by means of these puys.

Perhaps the description of the method of navigating these vessels, as given by Brand,† cannot be essentially improved: one man on each side of the vessel going towards the prow, puts down his pole to the bottom, in a position inclined towards the head of the keel; at the same time, thrusting against it forcibly with his shoulder, and walking down on the gangway towards the stern, as the keel moves under him; by this means the keel gains a tolerably quick and even course on the water: having walked the whole length of the vessel, they pluck up the puys, return hastily to the prow, put them down again, and thrust as

* *Keel-bullies* is a term used for this class of watermen—as bullies—probably derived from the obsolete adjective boolie, beloved—is a common appellation among the people concerned in the coal works for brothers. Brand mentions a pauper who, giving an account of himself and family before the officers of a parish in Newcastle, in order to obtain a settlement, told them (inter alia) that "his father had brought up six of them bullies," i. e. had brought up six sons. Such a clause, adds the relator, had it occurred in a deposition in the office at Bow-street, would have justly alarmed a London audience with the account of such a brood to be let loose upon the town!

† Hist. Newcastle, ii. 262.

before. Dr. Stukely thus describes the method of navigating keels, in his Itinerary, about the year 1725:—"The manner of rowing their great barges (at Newcastle,) is also very particular, and not unworthy of remark; four men manage the whole; three to a great and long oar, that push it forward, and one to another such a-stern, that assists the other's motion, but, at the same time, steers the keel, and corrects the bias the other gives it." "These

Fig. 42.

boats," says Pennant, "are strong, clumsy, and oval, and carry twenty tons a-piece; they are navigated with square sails, but generally by two very large oars, one on the side plied by a man (generally two men) and boy; the other at the stern by a single man, serving both as oar and rudder."

In discharging these river craft into the regular traders above Tynemouth, some of the coals are occasionally scattered overboard; these, with considerable quantities sometimes brought from the German ocean on the flowing of the tide, form the perquisite* of a

* A similar practice obtains at the mouth of the Wear: the persons waiting for the rising and recession of the tide, when small coals are left on the sands, present a scene of considerable activity and entertainment; for in their anxiety to obtain the advantages of being foremost, they frequently pursue the receding surge too far, when, by its reflux, they become drenched and sometimes immersed in water to the middle. It has been stated that before the establishment of various manufactories afforded better employment to the poor, as many as 500 persons at a time have been noticed pursuing this singular occupation. The common belief on the spot is, that most of the coal thus dragged up from the bed of the river, is part of the

number of poor people, who, with their little cobles, ropes, and nets, are constantly to be seen dredging for them in the Tyne between North and South Shields. The wives and daughters of the hardy race above-described, are called, from the service they perform, keeldeeters: they sweep the keels, and have the sweepings for their pains.

We find all business between the actual pitmaster or coal dealer at Newcastle, and the merchants arriving in that port by sea, was transacted toward the middle of the sixteenth century, by a class of local factors called "hostmen," in whose service the keels above-described were employed, and who, moreover, appear to have been the entertainers of the masters of coal ships, while the latter lay in the Tyne. According to Brand, the "oastmen" * had existed as a

cargoes of ships that have sunk out at sea: we recollect, however, on one occasion to have heard a gentleman contend, that as the quantity was greater than could be accounted for on the above supposition, it was more likely, assuming the hypothesis that the German Ocean itself was an immense coal-basin, that the small coal in question is, by the action of the tides, abraded from the basset edges of submarine strata, and then washed up the estuary.

* The cause of their appointment seems to be contained in the subsequent statute, 5 Hen. IV. cap. 9. (A.D. 1404,) Marchants Aliens. "And also it is ordained and stablished that in everie towne and porte of the sea in England, where the said marchants aliens or strangers be or shall be repairing, sufficient hoostes shall be assigned to the same marchants by the maior, sheriffes or bailiffes of the said cities, townes and portes of the sea; and that the said marchants aliens or strangers shall dwell in none other place, but with their said hoostes so to be assigned, and that the same hoostes so to be assigned shall take for their trauail in the manner as was accustomed in olde time." Statutes, by Barker. 1587. Here, the term "host" is used in the good old English sense of an hospitable entertainer; in the following Act, recited at a Court holden Feb. 3, 1600, Ann. Regine Eliz. 43, we find the word applied both to the master and the guest:—"Yt is further ordered by th' aucthorytye aforesaide the said day and yeare that no free brother of this felloship of hostmen shall henceforth either himself or his servants or any other for him, go or send to the sheeles [Shields] or the ballist shores or within any part of the ryver of Tyne or any place without the walles of the said towne to talke or speake with the owner, master or purser of any shipp, hoie, or other

guild or fraternity in the town of Newcastle from time immemorial, before their incorporation by royal charter, which is said to have been granted on the following occasion:—About the year 1599, Queen Elizabeth requiring of the mayor and burgesses of the town, the great arrears of a duty payable to the crown, of twopence per chaldron on coals sold to non-freemen in the port of Tyne, the date of the origin of which can only be conjectured, but of which there is express mention in a statute, A. D. 1420, it appeared, that the payment of this impost had been so long neglected, that they found themselves unable to comply with her request; on which they besought her Majesty to remit them the sum, and to incorporate the old guild of hostmen, who, on their incorporation, should, by a grant to the Queen, her heirs and successors, oblige themselves, and their successors, for ever, to pay one shilling for every chalder of coals exported from thence to the free people of England. So writes one author; but they themselves, in their own grant affirm, that they were influenced by more generous motives, and that what they did, arose from their gratitude to her Majesty for incorporating them by charter, as also to assist her, then labouring under excessive charges in support of the realm against its foreign enemies.

From an account of the state of the coal-trade at

vessel whatsoever upon the water to learne whose oaste he is, thereby to procure him to be his oaste or to withdraw him from his olde oaste by any kind of meanes, &c." The "hostelers" in the port of Yarmouth seem greatly to have resembled the hostmen in the coal trade at Newcastle, and were, like the latter, a kind of mediators between the buyers and sellers. Camden, in his Britannia, gives the following etymon:—"the word hostmen may not improperly be taken to be traders into the eastern parts of Europe, and may have their name from the Latin word *oustmanni*, i.e. the eastemen, as trading into those parts, as well as those who came from the sea-coast of Germany into Ireland, &c."

Newcastle-upon-Tyne, dated February 26th, 1602, and preserved in the books of the above fraternity, there appear to have been at that time twenty-eight acting fitters,* or hostmen, "who were to vend by the year, 9080 tons of coals, and find eighty-five keels for that purpose: the prices ordered were, for the best sort not above ten shillings the chaldron; for the second best sort, not above nine shillings; and for the third kind, called there, 'the meane coles,' not above eight shillings for the like quantity. A.D. 1603, complaint was made to the King, of great wrongs done to the mayor and burgesses of Newcastle-upon-Tyne by the hostmen of that town: this matter, which appears to have arisen from refusing to admit into that fraternity, such as were free of the twelve mysteries of the town, was referred to the Lord President of the Council at the work, at York, who made a decree, in consequence of which, great numbers out of the mysteries were admitted free hosts."† Twenty years afterwards, namely, in 1622, there were vended by the society of hostmen of Newcastle, 14,420 tons of coals.

During the struggle between Charles the I. and his Parliament, the coal trade suffered dreadfully: grievous imposts were exacted from the owners and dealers on the Tyne, who, partly from their loyalty, and partly from the insecurity of sea-going vessels afterwards, were almost ruined. Meanwhile, the in-

* This Society are also called "*Fitters*," from their immediate vocation being to "fitt and load coales abord the keeles." It is by this appellation that the members of the fraternity are better known of late years. Those illustrious jurists, Lord Eldon and Lord Stowell, were the sons of a coal fitter at Newcastle. It has been remarked, that in the printed journals of the House of Commons, the title of this fraternity is often by mistake spelled "fillers." There is no intervention of fitters in the sale of coals on the Wear.

† Brand, vol. ii. p. 273.

habitants of London, and especially the poor, were perishing for want of fuel. A more serious calamity had nearly befallen the coal-owners at Newcastle: when the Scots besieged the town, the Marquis of Newcastle ordered all the mines to be fired. This was only prevented by General Lesley's surprising all the boats and vessels.* When the town had been taken by the Scottish forces, the House of Commons took the management of the coal trade into their own hands; and a great quantity of coals were subsequently sent up to London, where they had previously risen to the enormous price of four pounds per chaldron.

Under the Protectorate, the collieries were set to work with redoubled vigour: the river swarmed with barges carrying coals between the staithes and the ships. In 1655, about three hundred and twenty keels appear to have been employed upon the Tyne in carrying the coal to the ships. In 1699, one thousand four hundred ships are said to have been employed in the coal trade, exporting yearly from Newcastle, two hundred thousand chaldron of coals † in time of peace. Newcastle had, at that time, two-thirds of the coal trade; three hundred thousand chaldrons in all coming annually to London. The over-sea trade in this article, at the same time, is said to have employed nine hundred thousand tons of shipping, the coal trade, indeed, being reckoned, at that period, the greatest body of English shipping.

In 1703, upon an inquiry of a Committee of the House of Commons, appointed to receive proposals,

* Whitelock's Memorials, p. 27.

† Newcastle measure; of which 136 chaldrons are equal to 217 London measure.

and prepare heads of a Bill for the increase of seamen, and the speedy manning of the royal navy, sent to the masters of the Trinity House of Newcastle, concerning the number of ships, &c., necessary for the coal trade: they were answered by that fraternity, that six hundred ships, one with another, each of eighty Newcastle chaldrons, with four thousand five hundred men, were requisite for the carrying on of that great branch of commerce. "A number," they added, "both of ships and men, that had been engaged therein for three years last past." In the following year, the Lords gave their assent to an Act for the increase of seamen, and security of the coal trade. From Christmas, 1704, to the year 1710, there appear to have been exported from Newcastle *communibus annis*, 178,143 chaldrons of coals; and from the port of Sunderland, in the same time, 65,760 chaldrons. Brand adds, that in the year 1764, there were exported from the river Tyne for London, and coastways, 20,000 chaldrons of coals, London measure, and 40,000 chaldrons like measure, for foreign parts, more than had been exported in any one year. In the same year, 3,727 vessels were cleared out of that river for the coast, laden with coals, and 365 for foreign parts; a greater number than ever was known before.

These statements, in some sort, anticipate the subject of the succeeding chapter, to which, perhaps, they more properly belong; but they are introduced here to show the vast extent to which, at the periods above-noted, our maritime and river population were engaged in the transit of one single article of fuel. When to the tonnage and manning of the ships above-mentioned, we add upwards of four hundred keels, and sixteen hundred keelmen employed on the Tyne

alone, we shall not doubt the propriety of an expression frequently used during the last century, and especially during the late war,—that *the coal trade is Great Britain's best nursery for seamen.* Most emphatically does the history of our marine attest the truth of this sentiment: but while recording the bravery and the loyalty of the hardy race of men, who were at first cradled upon the water in the coal barges, and inured to toils in the Tyne, the Wear, and the Tees, who does not feel a mingling sensation of shame for his honour as an Englishman, when he recollects how often those very men were conveyed, *nolens volens*, from their own craft on board King's ships, by the detestable system of impressment, so prevalent during past years!

Since the above passage was written, an unsuccessful attempt has been made in Parliament to relieve the nation from the odium of impressing its seamen. The subject, as connected with the Tyne, has likewise been worked up into a tale by Harriet Martineau—not, however, with the success displayed in some others of that series produced by this ingenious political economist. The kidnapping of these hardy keelers by press-gangs, for the manning of King's ships, is a crime of old practice. In 1693, the coal trade of Newcastle suffered great interruption, the keelmen there being afraid to work, on account of the impress for seamen; and in one quarter of the year 1783, five hundred and eighty-four keelmen took out protections to avoid being impressed to go on board his Majesty's ships of war; as did the next quarter, seven hundred and ninety-eight of the same body: many infirm individuals, and those above and under age to be pressed, took out no protections.

CHAPTER XIX.

THE LONDON COAL TRADE.

Early Legislative Regulations—Use of Pit Coal formerly prohibited in London—Growth of the Coal Trade—Duties laid upon Coal—Regulation of the Vend—Charges upon a cargo of Coals at the place of Shipment, and Coastwise—Charges in the Port of London—Enactments relative to the Coal Trade—Method of transacting business—Ship and Land Meters—Coal Bushel—Parliamentary Enquiries—Opinions of the Committees—Proposal to substitute Sale by Weight in lieu of Sale by Measure—Breakage of Coal—Sales by the Chaldron abolished by Act of Parliament, and Sales by the Hundred-weight authorised—Suspension of the Law respecting Meterage—Duties chargeable upon Coal—Discharge of the Cargoes of Vessels in the Thames—Progressive State of the Trade.

A SERIES of legislative enactments, which it would be tedious to detail here, from the commencement of the intercourse between the northern collieries and London, regulated the trade in coals to the metropolis, as well as the lighterage from vessels on the Thames,

and the modes of sale and distribution to the inhabitants. As evils have grown up in the existing system, or new provisions have been called for, these enactments have been revised by the Government for the time being; rarely, however, including the sacrifice of any of those numerous imposts on the commodity, which, accumulating through ages, rendered this kind of fuel so expensive to the consumers. London, however, has no particular reason to complain on the whole; and of late years, competition, and an abundant supply, have prevented prices from becoming oppressive; and this, notwithstanding the fraudulent practices on the part of the retailers, which appear to have been carried on to a great extent.

The use of sea-coal, as we have already seen, was prohibited at London, in the year 1306, by royal proclamation. Brewers, dyers, and other artificers, who had occasion for great fires, had even at that time, found their account in substituting this fossil for dry wood and charcoal; but, so general was the prejudice concerning it, that the Nobles and Commons assembled in Parliament, complained against the use thereof as a public nuisance, which was thought to corrupt the air with its stink and smoke. A regard to private interest caused the first proclamation to be but little noticed: on a second complaint, the King issued a commission of Oyer and Terminer, with strict orders to punish the delinquents by fines, and the demolition of their furnaces and kilns: it does not, however, appear, that this severe edict was less nugatory than that preceding it. Twenty years afterwards, sea-coals appear so far to have grown into estimation, as to have been used in the royal palace: and we hear nothing more of legal objections to their

use in London, though the prejudices against them, in some sort, continued long after the trade had become very considerable; indeed, almost until the popular complaint was transferred from the smell and smoke of pit-coal, to the wasteful consumption and decay of the forests.

The imposts subsequently laid upon the coal trade, have not only contributed to enrich the coffers of every Sovereign, from the time of Edward the Third, or earlier, but have, in one or two instances, been made directly advantageous to the city: for it appears, that Sutton, the founder of the Charter House, derived much of his wealth from the northern coal mines, leased to him by Queen Elizabeth, on advantageous terms. And, for the building, finishing, and adorning of St. Paul's Church, then rising over the ashes of the "great fire," there was given by Parliament, an imposition charged on sea-coal imported at the port of London, viz. of two shillings per chaldron or ton, from the first of May, 1670, to the 24th June, 1677; and three shillings per chaldron from the 24th of June, 1677, to the 29th September, 1687; and three fourths of the money raised by the former, and one half of the money raised by the latter Act, was to be employed towards the rebuilding of fifty-two parish churches; one fourth of the latter sum, was to be applied towards the rebuilding of St. Paul's. Again, by another Act of Parliament, 1 James II., an imposition on coals of eighteen-pence per chaldron or ton, was granted, to continue from the 29th of September, 1687, to the 29th September, 1700, two thirds whereof was applied towards the carrying on the building of this church. Before proceeding to detail the statutable regulations of the London coal

trade, it may be mentioned that at Newcastle, there exist certain regulations of long standing, which directly affect both price and supply. These are, more particularly, in the first place, what is called the "Regulation of the Vend," a sort of compact entered into among the principal coal owners, as to the amount of each quality of coal they shall respectively send to the market. The ostensible design of this agreement has always been, so to regulate the supply in reference to the demand, that ruinous fluctuations should be avoided. This object has, perhaps, been largely attained; at the same time, that its necessary tendency has been to keep up prices, by preventing competition; and since the opening of so many new collieries on the Wear and the Tees, the freedom of the vend is but little, if at all, controulable by any such compact on the part of the large owners. In the second place, there is a regulation on the Tyne, authorised by Act of Parliament, and which requires that all ships coming into the river for coals shall be laden in turn; the object being to prevent the giving a preference to particular ships; so that when a vessel arrives, she is put upon the list, and comes on for a cargo accordingly. This "Turn Act," which was renewed for twenty-one years, some years ago, has been complained of as causing the unnecessary detention of ships in the river, where it is estimated ten thousand arrive in the course of a single year: its influence, however, on the trade at Newcastle, has probably been, on the whole, beneficial hitherto.

The following are the charges on a cargo of coals from Newcastle to London, over and above the price paid to the coal owner. The ship is 204 tons regis-

ter, holds thirteen keels and two chaldrons, and is filled at the Spout on the Tyne :—

	£	s.	d.
Coast Duty, 1s. per chaldron,	5	6	0
Tynemouth Light, ¼d. per chaldron, and 1s. added,	0	3	2
Low Light, (ship above 200 tons,)	0	2	7
Trinity Lights, 1¾d. per ton, and 6d. added for Tees buoy,	1	10	3
Coast Lights, 3d. per chaldron,	1	6	6
Bridlington Pier, ¼d. per chaldron,	0	2	3
Scarborough Pier, ½d., and 8d. for Old Pier,	0	5	1
Whitby Pier, ½d.,	0	4	5
Night Office, 1d. per keel,	0	1	2
Foy,	0	5	0
Stamp,	0	4	6
Town Dues on Coals, 2d. per chaldron,	0	17	8
Do. on ship and boat,	0	4	2
Trimming 3s. 6d. per keel, and 6d. each for two chaldrons,	2	6	6
Cranage on Ballast, 45 tons at 6d. (filling 2d., cranage 4d.)	1	2	6
Corporation Assessment on Ballast, at 1s. 8d.	3	15	0
Ballast at London :—			
45 Tons Ballast, at 1s. 2 5 0			
Heaving in, 12s. per score, ... 1 7 0			
Booking, ... 0 1 0			
	3	13	0
	£21	9	9

To the above must be added,—

Spoutage, 6d. per chaldron.

Keel Dues, 2s. 4d.

Pilotage in and out, say £2.

Steam Boat, £1.

If the Ballast be delivered into keels, the charge per keel will be, for keel due and warrant, 24s., coasting, 14s.

	£	s.	d.
For two keels and warrants,	£3	16	0
For extra five tons,	0	10	0
	4	6	0

Making a difference between delivering by crane and keels, of £3 6s. 6d.

The annual bearing of these charges upon a collier ship will depend, of course, upon the number of trips made: but supposing a vessel from the Tyne to make ten voyages in the year to London, (fifteen have been made,) the charge from Newcastle would amount to £214 17s. 6d. At Sunderland, many of the above charges do not exist; so that upon ten voyages from the latter port, the imposts are only £142 15s.,—making a difference in the year of £72 2s. 6d. This is calculating the vessel as always delivering at Newcastle; whereas, were the ballast delivered into keels, it would make a farther difference in the year of £31 15s. 0d. It has, moreover, been asserted that, at Sunderland during the summer months, not one quarter of the vessels come into the harbour with ballast, but cast it at sea; and in the winter months, not more than one half.

By an Act passed in 1807,* the coal trade in London and Westminster, and in certain parts of the counties of Middlesex, Surrey, Kent, and Essex, (which had long been subject to regulation by law,) was, from the arrival of the vessel in the river Thames, to the ultimate delivery of the coal to the consumer, placed under a series of strict regulations, pursuing in minute detail every step of the business.

The following is a statement of the various charges upon a chaldron of coals in the port of London, as they were levied in 1830:—Government duty, 6s.; Orphan's duty, 6d.; City metage, 4d.; additional metage, 4d.; Deputy meters for wages or hire, (in discharging, per score of 21 chaldrons, 3s. 6d.;) in lieu of samples and other charges, (£1 1s. per ship,)

* 47 Geo. III. by which eleven previous Acts were repealed, one as far back as Edward VI.

and for provisions (calculated at 13s. 6d. per ship; i. e., 4½ days at 3s. per day) collectively, per chaldron, 3¾d.; coal heavers, or whippers, (nine for every ship, 3s. per score of 20 chaldrons;) meter's men, 3s. per score of do.; and undertakers 1d. per do.; together, per chaldron, 1s. 7d.; coal market duty, 1d.; Lord Mayor for permit; night office; collector of water baillage; clerks of coal meter's office, and of coal market;—these are rather customary than legal items, and are charged upon each ship, making per chaldron ½d.; tonnage duty, 1¾d.; Trinity and Nore light dues, ½d.; other charges, 4d. Total of charges, 9s. 4½d. per chaldron. There was a London duty of 3s. 4d. a chaldron taken off coals in 1824.

According to the above regulations, which remained in force until 1831, all coal brought into the port of London was required to be sold on the coal exchange.* When a vessel arrived, her papers were

* Some idea may be formed of the manner in which the business of the coal market was transacted, previous to 1797, from the following statement of Mr. Gillespy, an old coal factor, in his evidence before the Commons' Committee, in 1830. "When I came on the market, in the year 1775, it was a private building, owned by certain proprietors. It had been built about seven years before that time: before the year 1768, the coal buyers used to congregate together, upon what was called, Rome-land, an open place off Billingsgate, and when my father came on the market, in the year 1755, the practice was, for the factors and buyers to associate together among the fish people, and endeavour to make an arrangement so as to make a purchase of coals. The Act of the 9th Anne, made it indispensable, that the captain should be a party to such an agreement, and, therefore, whenever a factor could get one, two, three, or four buyers, who engaged to take a cargo of coals, he got them to a public-house in the neighbourhood; the first thing was to order something to eat and drink, the factor to pay for the room, and they sometimes concluded a bargain; at other times they parted without making a bargain, but the factor always paid the expenses, and they made a private bargain in the best way they could; it followed, of course, at that time, that no coals were sold, unless the whole cargo could be disposed of:—the practice at that period was, that there was generally something of a concealed price that was kept back, so that the price avowed to the public was

transmitted to the factors employed in the coal market, certifying the name of the ship, the port to which she belonged, the quantity and name of the coal she contained, the price paid, and the name of the port of shipment. The entry being made at the Custom House, the certificate was endorsed and filed by the receiver of the Lord Mayor's dues, and a copy of it sent to the clerk of the coal market, by whom it was publicly exposed on a board provided on the exchange for that purpose. The factor might then proceed to the sale, which could take place only between the hours of twelve and two, on Mondays, Wednesdays, and Fridays. The contracts were required to be entered in the factor's book, a copy was then given to the clerk of the market, after which the fitter's certificate, together with a warrant and certificate of the king's and the city dues being paid, were delivered to the clerk of the ship-meter's office, together with a turn paper, specifying the order of succession in which the different purchasers were to have their respective shares of the cargo delivered to them. After these forms were gone through, a ship meter was appointed to superintend the discharge of the cargo.

In October, 1831,* an Act of Parliament was passed, "For regulating the vend and delivery of coals in the cities of London and Westminster, and in certain parts of the counties of Middlesex, Surrey, Kent, Essex, Hertfordshire, Buckinghamshire, and Berkshire." The basis of this Act, as set forth in the preamble is, that—the Acts theretofore in force,

more than was really paid. The practice was to return guineas very much; one, two, or even four guineas were sometimes given back."

* 2d Guiel. IV. cap. lxxvi.

for regulating the vend and delivery of coals at the several places specified, having been found insufficient to prevent the commission of frauds and impositions in the vend and delivery of such coals, the objects intended to be effected by the said Acts would be more effectually promoted, while the rates and charges which tended to increase the price of coals might be reduced, if the said Act were repealed, and other provisions made in lieu thereof. The new Act, after repealing (from the termination of the year, 1831,) so much of the statute of 9th Anne, c. 28, as refers to the regulations detailed above, including also, portions of more recent Acts, substitutes a clause, requiring that every fitter or other person lading coals for the port of London, shall send a letter directed to the clerk of the coal market, and put into the general post-office, on the day on which the ship or vessel, containing coals, shall sail on her voyage, or shall give to the ship-master, before sailing, a certificate, signed by such fitter with date of lading, master and ship's name, quantity of coals on board, "the usual names of the several and respective collieries out of which the said coals are, and shall be, wrought and gotten, and the price paid by the master for such coals." Certain penalties attach to the intromission of false, or non-delivery of regular certificates, and an additional penalty of threepence per ton, when coals exceed the quantity mentioned in the fitter's certificate, by 5lbs. in 100lbs.

Previous to the passing of the late Act, a complicated and expensive part of the machinery connected with carrying on the trade in London, consisted of the system of meterage, organised ostensibly for the protection of the public, and also to assist in the collection of various municipal and other dues.

Fifteen principal ship meters, and one hundred and fifty-eight deputy or working meters, whose number was, on the alteration of the law in the year 1824, increased from one hundred and eighteen, were appointed by the city of London. The principal meters superintended the deputy or working meters, whose duty it was to ascertain and certify the quantity of coal measured out of the ship; and each deputy meter appointed an assistant, who worked with him in the delivery of the cargo. In order to effect this object, a vessel called a vat, containing nine bushels, was placed on the deck; it was filled from a basket in which the coal was raised from the hold, and was deemed to be full when a regular cone, twelve inches high, was formed on the top; the vat was then emptied over the ship's side into the barge, which barge was divided into compartments or *rooms*, as they were called, holding usually either ten or five chaldrons, pool measure.* According to the quantities thus ascertained by the ship meter, not only the public dues and duties were paid, but also the freight, and price agreed for by the persons who had purchased the cargo calculated. It was also the duty of the ship meter to transmit an account of the quantity of coal measured from the ship to the ship meter's office, to the clerk of the coal market, and to the office of the principal land meter.

The cargoes of coal ships have long been almost exclusively delivered by persons called whippers, usually provided by undertakers—the latter, too often connected with publicans and shopkeepers, and whose practice has been to compel the gangs of men whom they choose to employ, to purchase liquor and goods

* Pool measure is one fourth of a chaldron extra on every five chaldrons.

of those persons upon very disadvantageous terms—a whipper, whose pay was regulated by the Act, often being compelled to pay two shillings a-day for gin, or beer, whether he drank it or not. The barges employed were usually the property of the coal merchants, and were not subject to any particular regulations. It is provided, however, by the Waterman's Act, that no person shall navigate such barges on the Thames who is not a freeman of that Company. When the coal reached the Merchants' Wharf, the superintendence devolved on a different class of persons, also legally appointed. Neither the coal merchant nor the buyer had any controul over the measurement of the coal; this was entrusted by law to the land meters: of these persons, there were four divisions; one in the city of London; one in Westminster; one in parts of Middlesex; and a fourth in the county of Surrey. It is to be observed, however, that parts of the metropolis within the county of Kent, and the principal part of the Regent's Canal, were free from any such controul. The land meters were entitled to sixpence a chaldron for all coal sold by wharf measure, and one shilling for every five chaldrons sold by pool measure. It was the duty of these persons to superintend the actual measurement of all coal removed from the barge; to see the bushel properly filled, and three bushels placed in each sack before it was carried away. In the sacks, thus filled, it was directed by the then existing law, that all coal should be delivered to the consumers.*

* To persons visiting London from the country, few objects have appeared more striking than the waggons and horses of the coal dealers. Gay, in his "Trivia," alludes to the bulk and number of those teams, which in his time blocked up the streets:—

"Where the fair columns of St. Clement stand,
Whose straitened bounds encroach upon the Strand;

The coal bushel was a metal cylinder, 19½ inches diameter inside, 7⅛ inch deep; and in filling it, the coals were to be heaped six inches high in the middle, so that a line drawn from the apex to opposite sides of the bushel, would be 11½ inches in each direction. It will readily be perceived how, in measuring such a commodity as coal, the quantity called a bushel must in reality frequently vary much; not only as it might happen to be of a larger or smaller kind, but according to the management of the meter; for although by the use of a sort of strike called a triangle, the cone of small coal might be pretty accurately estimated, yet when the commodity consisted of large irregular shaped pieces, the case was widely different. In the delivery of coal to the public, a bushel measure was required to be sent with each waggon, and the purchaser was by law entitled to require any one sack to be measured; if that were found deficient, he was then at liberty to send for a land meter, and to require the remainder to be measured in his presence. A very large proportion of the inhabitants of the Metropolis, however, derived no benefit from a regulation involving such unpleasant details, where doubt was entertained,—and which,

Forth issuing from steep lanes, the collier steeds
Drag the black load; another cart succeeds;
Team follows team, crowds heaped on crowds appear,
And wait impatient till the roads grow clear."

"The horses of the colliers," says Leigh Hunt, "are worth notice at all times from the magnificence of their build." Southey has noticed the men: "The most singular figures in the streets of the Metropolis," says he, "are the men who are employed in carrying the earth-coal, which they remove from the barge to the waggon, and again from the waggon to the house upon their backs. The back of the coat, therefore, is as well quilted as the cotton breast-plate of our soldiers in America in old times; and to protect it still more, the broad flap of the hat lies flat upon the shoulders. The head consequently seems to bend unusually forward, and the whole figure has the appearance of having been bowed beneath habitual burdens."

besides, afforded no protection to purchasers of less than nine bushels. The poor especially were exposed to hard, if not to fraudulent, dealing, without redress, as they mostly buy coal from chandlers and other small retailers, and in these purchases the meter was not authorised to interfere.

Such had been the progress, and such were the existing regulations of this important branch of our national commerce in 1830, when a Select Committee of the House of Commons was appointed "to enquire into the State of the Coal Trade, in the Port of London, with respect to the several Acts and regulations affecting the vend and delivery of coals within the Cities of London and Westminster and Liberties thereof, and in certain ports of Middlesex, Surrey, Kent, and Essex: and also to enquire into the price and charges of coal to the port of London, and at the port of shipment, and whether any and what restrictions exist with regard to the supply of coal," &c. In pursuance of these authoritative instructions, the Committee examined a number of persons connected with every department of the enquiry; from these individuals, they derived an ample body of evidence, which, with the report founded thereon, was ordered to be printed: from this report several of the foregoing particulars are derived.

It was the opinion of the Committee in the first place, that the sum of 13s. 9d. usually added by the merchant to the price of coal in the river, to cover expenses, would be reduced, if the merchant were allowed to conduct his business with less restraint; the interference of the land meters producing a degree of delay to which the advantages derived from them did not appear to be at all equivalent: indeed,

besides the inconvenient delay in the discharging of vessels, and the irregularity of the metage as managed in different places, or by different parties at the same place, it was shown in evidence that, in one district at least, "three-fourths of the coal went away without being measured by the meter." The Committee, therefore, on the ground that the expense and inconvenience produced by the system of land metage were not compensated by any security to the public, gave it as their opinion that, if coal were to be delivered by weight, and every facility were afforded to the purchaser for seeing it weighed, the public would be considerably benefited. The Committee were likewise of opinion, that the system which the law had provided for the discharge of coal from the colliers into the barges, was altogether defective; not only did they deem the allowance made by law to the whippers, amounting to 3s. for each score of twenty chaldrons, to be much higher than the current market price of labour; but they demonstrated that much abuse had arisen in the distribution of such excess. As all the witnesses concurred in stating, that in ports which were free from these regulations, the discharge of the cargo was much more economically conducted, the Committee recommended the repeal of the existing regulations in this respect, leaving the owners to provide their own means of unloading their vessels.

It appeared in evidence, that the total payments made to ship meters, assistants, and whippers, on 1,503,581 chaldrons imported in 7,031 ships, in the year 1829, were as follows:—

Meters, ...	£33,690	19	4
Meters' Men, ...	11,951	17	0
Whippers,.........................	107,566	13	0

As these payments appeared to be unnecessarily large, the Committee considered whether the ship as well as the land meters could not be altogether dispensed with; they were, however, of opinion, that as a sum of about £90,000 is collected annually by the city of London under various trusts, the continuance of the meters for that purpose might be desirable; and moreover, that so long as they continued to be so employed, they should also be employed in ascertaining and charging the King's duty. The Committee, however, considered it of the utmost importance, not only that a change should be made in the mode in which the business of the ship meter was conducted, but that some adjustment or modification of port dues should, if possible, be effected. As a reason for this recommendation, they referred to the apparent difference between the number of chaldrons of coal shipped and the quantity actually delivered. This striking fact was illustrated by the result of twenty-two cargoes of the same coal, carried in five ships, making together so many voyages. The average of these cargoes proved that the Newcastle chaldron, as put on board, made out in the pool eight per cent. more than the double chaldron (of two London for one Newcastle); or than a keel of coals of eight Newcastle chaldrons.

That the system of breakage notoriously carried on with all sorts of coal,* both during the voyage and afterwards, for the purpose of increasing the bulk,

* Captain Cochrane, one of the owners of Hetton Colliery, stated on his examination before the Committee of the House of Lords, that "it is by no means uncommon to see the boys in the hold, breaking the coals with hammers as they are shipped; they are again," he adds, "broken when they come to London, for the purpose of getting an excess of measure." He mentions an instance where the breakage made a difference of 30 chaldrons in 253.

should have been reluctantly acknowledged, was what might have been expected: but it was surprising that some persons should gravely have professed to doubt whether coals broken into small pieces really did occupy more space than before!* It is probable, indeed, that in every instance, the excess of London pool over Newcastle measure was not so great as it appears to have been with respect to the above-mentioned cargoes; but it is a well-known fact, and probably not better known to any persons than those in the trade, that coal occupies considerably more space when broken than when solid. The accuracy of the late Dr. Hutton's statement on this subject, was confirmed to the Committee by Mr. Buddle. "If one coal," says Dr. Hutton, "measuring exactly a cubic yard (nearly equal to five bolls), be broken into pieces of a moderate size, it will measure seven bolls and a half; if broken very small, it will measure nine bolls." There was no part of the trade, from its earliest stage to the last sale to the consumer, which was not affected by the inducement to break the coal in order to increase the measure. And so far was the screening of the coals which had previously taken place at the pit mouth, with such im-

* Another specious objection urged against the sale of coals by weight, on the part of those interested in the retention of the breakage system, was, that the weight would be increased by wetting, and thus the public would be cheated. But, as Mr. Edington, in a Treatise on the Coal Trade published several years ago, remarked, "the contrary is more likely to be the case; for if a bushel of Wallsend coals be measured up dry, it will shew its weight to be from eighty-four to eighty-five pounds: then try another bushel of the same coals well wetted—the weight will be found not so great; for the fact is, a bushel of dry coals, if ever so round, has always a part small, which runs like dry sand, and fills up cavities, making the whole a solid mass; whereas a bushel of wet coals only closes up the hollow cavity, and they clog together and will not weigh so much as the dry coals."—*Treatise*, pp. 191-192, and 200.

mense waste, from being of any ultimate advantage to the consumer, that Mr. Brandling, in his evidence, declared the coals were reduced to a state, before they were delivered to the retailers, inferior in point of size to what they would have been if put on board unscreened.

In recommending so considerable a change as the substitution of weight instead of measure, throughout the whole of the London coal trade, it was necessary to consider the interests of individuals, as they might be affected by any mode which should be adopted in charging the duty. With that view, the Committee not only examined evidence, but caused experiments to be made, as to the specific gravity of different sorts of coals. It was the opinion of some witnesses, that the increase of weight which might be given to coals by wetting them, would open a source of fraud, little if at all inferior to that complained of from uncertain meterage. It was obvious, however, as well from the nature of the substance, as from various trials, that large coals would sustain but little moisture comparatively; and, moreover, that watering could not take place to any considerable extent, upon either large or small, without its effect being very apparent: whereas, in measuring, the strictest surveillance often failed altogether to protect the purchaser. As to the gravity of different coals, the Committee found no such difference in the varieties raised in Durham and Northumberland, as to render weight an unfair criterion between them: and the result of experiments as to the average weight of a chaldron of coals as delivered in the port of London, led to the conclusion, that if the chaldron was taken at 25½ cwt., and the charges made on a ton in the proportion of 20 to 25½,

or 4s. 8¼d. to 6s., the benefit of whatever error might exist would be given to the public.

Having given the foregoing brief abstract of the voluminous evidence laid before Parliament, pending the contemplated alterations in the laws affecting the coal trade, it remains to be mentioned that, in pursuance of the recommendations of the Committees of both Houses, the sale of coals, culm, and cinders by measure, was abolished within all ports of the cities of London and Westminster by the Act of 1831, before adverted to. This Act likewise abolished in the same places, the office of land coal-meter; at the same time, authorising the Corporation of London to pay, out of the funds placed at their disposal, such compensation to the parties removed, for the loss of their situations, as the said authorities should think proper; including the continuation of annuities to such superannuated meters as might have been so provided for previous to the passing of the Act.

The corporation funds adverted to, will arise as follows: the metage jurisdiction of the city authorities, anciently granted to them as conservators of the river Thames, is suspended for seven years; meanwhile, the Act of 1831, gives them a duty of twelvepence per ton on all coal, culm, and cinders, brought into the port of London, to be applied for the purposes set forth in former Acts. The claims of the Corporation to dues for groundage and water baillage, are also suspended for seven years. Inland coals brought into London by the Grand Junction or Paddington Canals, pay thirteenpence duty additional, instead of fifteenpence as formerly.

As the new regulation required that all contracts, existing at the time the Act took effect, although

entered into with reference to the old system of measure, should be fulfilled by the substitution of a delivery by weight, it was enacted that, for such purpose, " twenty-five hundred weight, and the half of another hundred weight," should be considered and taken as equivalent to one chaldron.

By the aforesaid Act, the Coal Exchange, (which is stated to have cost £60,000), with its site, buildings, and appurtenances, as vested in the Corporation of London by the Act 47th Geo. III., is to continue so vested. It is, moreover, declared to be a free and open market for the sale of coals brought into the port of London, and is to be denominated the " Coal Market." Its government and sustentation are described by the Statute. A duty of one penny per ton on coals, culm, and cinders, arriving within any part of the port of London, or westward of Gravesend, is authorised to be levied for defraying the expenses of the Coal Market, &c.

In reference to the removal of coals from ships in the Thames,* although the work is not absolutely thrown open to whomsoever will do it best and cheapest, the sphere of competition is considerably enlarged: lightermen are allowed to enter into partnership with woodmongers, coal dealers, and others, as carriers of coals, provided such co-partners as are

* The coal ships in the Thames are delivered, as already stated, by a class of men called " Whippers," who were formerly paid at the fixed rate of three shillings for twenty chaldrons: they have sometimes been known to deliver as many as 205 chaldrons in a day, on extraordinary occasions: they could, however, work 105 with ease. They consist in great part of Irishmen; and since the new regulations have somewhat opened this department of the coal trade on the river, competition has been the consequence,—certain gangs being willing to deliver ships at a penny per ton, while others demand five farthings. Frequent disputes and conflicts ensue; and the Police Magistrates are frequently called upon to maintain the peace between these penny and five farthing men, as they are called.

not lightermen, do not enter into the business of conveying in lighters, barges, or other craft, for hire, any description of goods whatever, except only such coals as may be lightered by them in their trade of coal dealers. When the quantity of coal exceeds five hundred and sixty pounds, a ticket is given by the seller, specifying the sort of coal contracted for, the number of sacks, weight of each sack, &c. These sacks are required to contain either one hundred and twelve pounds, or two hundred and twenty-four pounds net—except when the coals are delivered by what is called "gang labour," when the quantity contained in the sacks is left undetermined. The late Act also authorises the delivery of coals in bulk, provided that the weight of the cart or other carriage, as well as that of the coals, be correctly ascertained, by a weighing machine erected for that purpose on the wharf, so that the carman can be made clearly responsible for the delivery of the specified weight, under a penalty, to be levied according to the amount of any deficiency that may be discovered.

Every carman, taking out coals for sale, is required to have a weighing machine, (previously proved and marked at Guildhall), attached to his carriage,* and with it, the carman is required to weigh any sack or

* In 1831, the large silver medal of the Society of Arts, was given to Mr. Braby, for a machine for weighing coals in sacks. This contrivance consisted simply of a horizontal bar of iron projecting behind the waggon, and parallel with the sides, to one of which it is fastened. Upon a hook at the end of this bar is suspended a steelyard, having at one end a scale which hangs by four chains from a top-board for the reception of the sack, and at the other end a pendant weight, which will counterpoise two hundred weight in the scale. But as a sack of coals weighs something more than two hundred weight, this excess is ascertained by means of a small moveable weight, which slides along the graduated lever-arm: it also serves, when the coals are poured out, to ascertain the weight of the empty sack—thus giving the exact weight of the commodity to a quarter of a pound.

sacks upon delivery to his customers: this weighing to take place in the presence of a constable, if the purchaser chooses to call one. Stationary weighing machines are also erected in convenient situations; and no quantity less than 560 pounds of coals is allowed to be sold and delivered without being weighed.

While recognising the great improvement which has been effected in the London coal trade by the substitution of the steelyard for the bushel, it must not be imagined by persons little conversant with the subject, that the sale of coals by weight was, on the coming into operation of the Act so often adverted to, absolutely a new thing on the banks of the Thames; for the fact is, that the practices both of measuring and weighing obtained at once, early in the seventeenth century; and a charter of 12th James I. to the Corporation of London, recites that his Majesty had given to the Mayor, and Commonalty, and Citizens, and their successors, "the weighing of all and singular coals, called stone coals, pit coals, earth coals, and all other kinds weighable, of what kind, nature, and species soever."

Some idea of the extent of this trade may be derived from the following statement:—In 1826, the amount of coal, culm, and cinders, imported into the port of London, was 1,600,229 chaldrons equal to 2,040,291 tons, 25½ cwt. being reckoned a chaldron, as required by the late Act. At that time, the duty paid upon the coal and cinders, was six shillings per chaldron, and upon the culm sixpence;—the entire importation produced £467,852. In 1830, the importation was so nearly on a par with that of 1826, that there was only the difference of about £100, in the amount of

duty paid. From the 1st of March, 1831, these duties were repealed; and in the following year, (1832,) the total quantity of the above descriptions of fuel imported at London, was 1,677,708 chaldrons, or 2,139,078 tons, the amount of the preceding twelve-months. In 1833, the quantity of coals stated to have been sold in the London coal market, was 2,006,653 tons, of which the proportion of Stewart's Hetton, and Lambton's Wallsend—the sorts considered best for ordinary purposes—was about 504,695 tons. The price of delivering these sorts at the cellar of the consumer, seems to have been 26s. per ton.

Another account makes the amount much larger. According to a return lately made to the House of Commons, the quantity of coals brought coastwise and by inland navigation into the port of London, in 1833 was 2,014,804½ tons, and 1834, 2,080,547 tons. Of these, there came from Newcastle, in 1833, 1,060,839 tons; in 1834, 1,142,903 tons; from Sunderland, in 1833, 666,787 tons; in 1834, 559,105 tons. From Stockton, in 1833, 170,690 tons, in 1834, 64,268. From Hull, Goole, Gainsbrough and other places in Yorkshire, in 1835, 17,751 tons. At present, the current London prices are—best Stewart's Hetton, or Lambton's Wallsend, 29s. per ton; best Newcastle, 27s., second, from 25s. to 27s.

CHAPTER XX.

IRISH, SCOTCH, AND WELSH COAL TRADE.

Importation of Coals into Ireland—Dublin supplied from Whitehaven—Various Coal ports—Legislative Regulations—Sales by Weight and by Measure—Coals allowed to be imported duty free, for certain Manufactories—Scotland behind England in the methods of working Collieries—Coal taken to Scotland duty free—Sold by Weight—Scotch Coal sent coastwise—South Welsh Trade—Newport—Small Coal, or Culm—Coal Balls.

IRELAND, although containing within itself strata of bituminous coal, and, especially, a vast deposit of anthracite at Kilkenny, imports a large quantity of the former description of fuel from various parts of Great Britain. The principal sources of supply are Whitehaven, in Cumberland; Ayrshire, in Scotland; and South Wales. The city of Dublin is chiefly supplied from Whitehaven; the exports from the latter place to Ireland having been, in the year 1828, upwards of 186,000 imperial chaldrons; in addition to 16,328 chaldrons from Newcastle; 44,856 tons from Liverpool; and 13,250 tons from Lancaster.

The importation from Scotland during the same year, was 105,933 chaldrons. The Welsh coals are shipped for Ireland mostly from Newport, Cardiff, and Chester; and amounted in 1828, to 142,738 tons, exclusive of upwards of 20,000 tons of culm. In addition to the consumption in Dublin, great quantities of coal are brought to the Irish ports of Cork, Belfast, Waterford, Newry, Wexford, Drogheda, Dundalk, Limerick, Londonderry, Sligo, Galway, Westport, Coleraine, and Baltimore; the relative importance of these places, in regard to the coal-trade of Ireland being according to the above order of enumeration. The total amount of coals imported into Ireland, in the year 1828, was 777,575 tons.

Coals for the above ports from Wales have long been put on board by weight: to ascertain this exactly, the waggons, previously weighed while empty, and marked, are, when full, run upon a machine placed in the line of the railway for the purpose, so that the weight of the contents of each can be immediately ascertained. Considerable inconvenience having formerly arisen from the manner in which the coal trade was carried on in Ireland, and particularly in Dublin, a succession of statutes, commencing with the reign of Queen Anne, had been obtained for more effectually preventing the engrossing and regrating of coals, and also for preventing abuses in consequence of combinations to raise the price of the commodity. These statutes were repealed by an Act passed in 1832, with the exception, that the impost of one shilling per ton, upon all coal and culm landed within the city of Cork, is continued.

As one great source of fraud and litigation had been the substitution of a superior denomination in

lieu of the proper name, upon inferior descriptions of coal, especially in reference to that taken from Whitehaven, the last Act requires, that on a conspicuous part of every vessel, in which coals shall be publicly offered for sale in any port, harbour, or river in Ireland, there shall be affixed a board or label painted with the reputed name, or commonly received denomination of the coals; and also the name of the port from which the cargo has been brought, together with the prices at which the coals are offered for sale; in default of a compliance with which regulation, a penalty of ten pounds is incurred.

Coals, which were formerly sold in Dublin by measure, as latterly in England, and under the superintendence of authorised meters, as well for the protection of the public, as to facilitate the collection of certain dues, have for many years been mostly sold, and the city duty of 1s. 9d. per ton, charged by weight; a small steelyard being for this purpose placed on the deck of the ship. The validity of sales, however, was made to depend upon the presence of the officer, until the passing of the Act of 2 Will. IV. rendered the employment of licensed meters and weigh-masters optional on the part of buyers and sellers, who were declared to be at liberty to employ whomsoever they might think fit, in connexion with sale, measurement, weighing, delivery, or storage. Six months after the passing of the above-mentioned Act, another was passed, giving compensation to the coal-meters according to certain specified terms; for which object, fourpence per ton is levied upon all coals, not Irish, brought into the city of Dublin, and no vessel is allowed to discharge her cargo until the duty is paid. These duties which are but tempo-

rary, may be reduced as the annuitant meters die off, or accept certain situations of emolument; and they are finally to determine and cease altogether, when there shall remain no longer any claimant according to the statute. But, pending that issue, there is a clause exempting from the aforesaid duty of fourpence per ton, all coals imported into Dublin, for the *bona fide* use of the glass, sugar, and salt manufacturers, and for the use of distillers, brewers, calico-printers, iron, brass, and metal founders; paper, woollen, and linen manufacturers; dyers, chemical workers, and all other coals required for the use of manufactories. For these purposes, the consumption is very considerable, while in private houses, especially in situations remote from the capital, this valuable fuel is much too expensive to become common. It will, however, be recollected, that in addition to native and imported coal, Ireland is abundantly supplied with peat, which, not only is the common fuel of the poor, and indeed of all classes, in some districts, but it is also brought in barges by the grand canal, and consumed to a great amount, along with, or instead of coal in the capital itself.

Scotland, as already stated, contains vast deposits of various kinds of coal; but, notwithstanding this fuel has been worked in that country for a period of five or six hundred years,* the drawing and pumping machines, no less than the underground arrangements, were until lately in every respect much behind those of our English collieries: even the system of tubbing back the water by the erection of a sheathing of tim-

* The first mention of coal that occurs in any charter relative to Scotland, occurs in a grant, executed in the year 1291, in favour of the Abbot and Convent of Dunfermline, and the privilege of digging coal in the lands of Pittencrieff, in the county of Fife.

ber inside the shaft, a practice almost universal in the Northumberland collieries, was only introduced a few years ago. The introduction of cast-iron tubbing, which is at once so durable and convenient, was first effected by Mr. M. Dunn,* at Preston Grange Colliery, near Edinburgh, in 1830. This gentleman was also the first to introduce the practice of tubbing into Ireland, he having applied it for the first time in the sinking of one of the Castle Comer pits in the county of Kilkenny, where a plank sheathing of ten fathoms long, supported by inside cribs, accomplished the winning of a tract of coal, without that method unattainable.

The consumption of coal, culm, or cinders in Scotland is not burdened with any duty, as the commodity is both imported and carried coastwise without restriction; a drawback being allowed upon all coal re-shipped for Scotland from any port in which it may previously have paid the duty. This circumstance, while it gives to the country all the advantages of an open trade, at the same time brings the Newcastle traders into direct competition with the Scotch colliers almost at the very mouth of their pits.

Edinburgh is mostly supplied with good coal, assimilating to the English in quality, from pits in the neighbourhood; especially from the collieries of Lord Elgin. The coals were formerly sold by measure in the city, but fraudulent tricks being common, and complaints consequently arising, as in the sister capitals, the Magistrates resolved that they should be sold by weight, and to facilitate this object, they established steelyard weighing machines at conve-

* Mr. Dunn received in 1832, the first silver medal of the Edinburgh Society of Arts, for the application of cast-iron tubbing in Scotland.

nient corners of the streets, where any person may have his purchase weighed. The waggoner who takes the coals, receives a ticket from the coal agent specifying the weight of the load; and if a purchaser chooses to have it weighed at any of the machines, and finds it short of the quantity charged, the carman is liable to make good the deficiency. Coals are likewise sold by weight in the city of Glasgow, which is well supplied from the collieries of the Duke of Hamilton, Mrs. Dixon, and a great number of others, in the immediate district. In 1828, there was shipped from Scotland and sent coastwise to various parts of Great Britain, 233,338 tons of coal; to Ireland, as we have already seen, 40,295 tons; to the British Colonies, 18,635 tons; to other foreign countries, 13,305 tons, making a total of 305,573 tons. During the same year, the quantity of coals imported at the following places collectively, viz.:— Leith, Dundee, Montrose and Arbroath, Banff, Greenock, Aberdeen, Kirkaldy, Inverness, Grangemouth, Thurso, Dumfries, Irvine, Lerwick, Stornoway, Kirkwall, Port Glasgow, Borrowstoness, Stranraer, and Campbeltown, amounted to 283,059 tons, charged by weight; to which has to be added 194,109 chaldrons, sold by measure.

The immense size and vast contents of the great Welsh coal basin, have been previously adverted to. From that all but inexhaustible depository, prodigious quantities of the various kinds of coal are sent to different parts of the United Kingdom: the working of collieries having amazingly increased of late years, owing in great part to the extended advantages of canals, and rail or tram roads. Mr. Coffin stated in 1829, that twenty years previous, there were hardly

any coals shipped in Newport—perhaps not a thousand tons in the course of the year; whereas, at the period named, the shipment amounted, collectively in that port alone, to nearly fifteen hundred tons a day.

There is, as already intimated, an extensive trade in coal carried on between South Wales and Ireland. The ports of shipment are principally Cardiff and Newport, Swansea and Neath; and the vessels used, are generally from 120 to 200 tons burthen. The quantity sent from the former of these ports in 1829, has been stated at about 60,000 tons; and from the others, at about 550,000 tons. Newport enjoys an exemption from the duty of four shillings per ton collected upon Welsh coal shipped from every other part of the Principality. This advantage was given during the reign of George the Third, by an Act which declares all vessels going to the eastward of the Holmes, (two islands in the Channel), to be duty free. As this regulation gives almost the exclusive benefit of the Welsh coal trade between Bridgewater and Bristol, to Newport, the shippers of Cardiff, whose harbour is only excluded by falling about half-a-mile on the wrong side of the line drawn from the Holmes, loudly complain of the preference: at the same time characterising it as "a clause *slipped into* the Monmouthshire Canal Act."

The exemption from duty here alluded to, had the effect of opening up coals at a greater distance from the market than otherwise they might have been—the Newport coals travelling, on an average, from twelve to fifteen miles by the tram-roads: they are consequently considered to be dearer than coals that have only to be carried half that distance to the shipping port, by the amount of such extra haulage and

tonnage; the consumer having sometimes had to pay six shillings a ton at Newport, when the same might have been purchased at Lydney for 3s. 6d. In reference to this matter, David Mushett, Esq., a well known iron and coal master of Gloucestershire, stated, in his evidence before a Committee of the House of Lords in 1830, that, while at Lydney, the small coal was required to pass through a three-eighths of an inch riddle, Newport shipped it without either riddling or duty in the markets within the Severn. The ports of Swansea and Neath, which are not within the Severn, were permitted, it was alledged, and contrary to regulation, to ship all their small coal at the lower duty, and subject nominally to a two-inch riddle, though seldom enforced, even of this large size. The coal here alluded to is not only small, but considered to be of a very inferior quality. Mr. Mushett says, that in 1828, not a single ton of that description was sold at Lydney, whereas there was shipped during the same year at Swansea, upwards of fifty thousand tons of small coals, nominally subject to a two-inch screen; not a binding coal, but a free burning coal. It was shipped under the denomination of bastard culm; it is in an intermediate state between stone coal and bituminous coal; it burns easily, with a little flame, but does not adhere much together. In the same year, the stone coal culm exported from Swansea was upwards of sixty-four thousand tons: it is chiefly used in the furnaces of steam-engines, and for smelting. When these coals from the Welsh ports are shipped for foreign markets, the owners of the vessels are obliged to enter into a bond that the vessel shall proceed to the port for which it is cleared out. Stone coal culm,

from its slow combustion, and the long steady heat it is capable of affording, is well adapted for lime burning, and large quantities are exported for that purpose: mixed with clay so as to form balls, it is also used in Wales for domestic purposes. In the cottages of the peasantry in the counties of Glamorgan and Carmarthen, and more especially in Pembrokeshire, these balls form the principal article of fuel. The culm and clay, being first thoroughly mixed by the bare feet of one or other of the female part of the family, are moulded into balls of an oval shape, and the good housewives not unfrequently display their taste by the fanciful way in which they place these balls edgewise in the grate, each row being inclined at a different angle; and, under the active influence of that passion for whitewashing, (which extending from the church belfry to the pig-sty, adds very materially to the picturesque nature of Welsh scenery,) they are not unfrequently, together with the bars of the grate, whitewashed also. These balls are, as may readily be supposed, difficult to ignite, but being once lighted, burn for a great length of time, and being renewed at the top as they slowly consume, the fire is not allowed to go out, in some cases, for many years; such a catastrophe would, indeed, be regarded by a thrifty housewife, as an unlucky omen. The appearance presented by a fire of this description, with various articles of linen hung up to dry, absolutely in the chimney, (for the balls, like stone coal, emit neither smoke nor flame,) is not a little singular to any one accustomed to the "bleezing ingles," and "black diamonds" of the North of England.*

* Forster's Observations on the South Welsh Coal Basin, in Trans. Newcastle Nat. Hist. Soc. vol. 1, p. 94.

CHAPTER XXI.

CONVERSION AND PRODUCTS OF COAL.

Manufacture of Toys, &c. from Glance Coal, Cannel Coal, and Jet—Pulverised Coal—Copperas—Bituminous Products of Coal—Pitch Lake—Early Experiments on Mineral Tar—Natural Fountains of Gas—Earl of Dundonald's Patent—The Distillation of Coal—First exhibition of Artificial Gas—Manufactured for purposes of Illumination—Residual Matters—Ammoniacal Liquor and Coal Tar—Incineration of Coal—Hard and Soft Coke—Processes of Preparation—Branching Coal—Smoke, Soot, and Ashes.

THE more direct conversion of coal in substance, into a variety of articles, has been already mentioned in a previous Chapter: it need, therefore, only be repeated here, that while glance coal is, in some countries, largely appropriated to the formation of trinkets, as cannel coal is in our own, it is to the depositories of jet, the most perfect of the lignites, and itself a species of coal, that the English artist is indebted for the material most highly prized as a substitute for black amber. This substance, of undoubted ligneous origin, is frequently met with in

the sandstone rock about Whitby and Scarbrough, from whence it is sent to London and Birmingham: it occurs in pieces of various sizes, and is valuable according to its quality. There is an immense block of beautiful jet from the former of the above localities, in the Museum at Newcastle. When of fine grain, it yields freely to the file, and to the tools of the turner; and vast quantities of it are annually consumed in the manufacturing of beads, crucifixes, brooches, boxes, and other personal ornaments and toys.

Coal, in a pulverized state, is an article of commerce, there being a manufactory of coal and coke dust at Wigan, in Lancashire: and it is said of the celebrated John Galt, that in early life, he read many books on astrology, alchemy, and witchcraft; and from the study of such occult subjects, he seems to have imbibed some strange notions, which his strong sense has not altogether eradicated. The only useful result of his study of the black arts, was the appropriate discovery, that coal pounded to an impalpable powder, makes an imperishable black. Galt hints, that this might have turned out a profitable speculation, had he pursued it: and he generously promulgates it for the benefit of modern practitioners of the black arts, whether in ink, blacking, or paint-making.

If we take a lump of coal, of a certain description, and expose it for a time to the influence of moisture—say to the rain, and then evaporate the liquid in which it has lain, we shall obtain sulphate of iron, or green vitriol. If the coal be next submitted to a strong heat in an iron retort, and the fume which arises be passed through water, the obviously resulting products will be hydrogen gas and coal tar,—the former æri-

form and highly inflammable, the latter a black odorous liquid. Having yielded these matters, the contents of the retort will have taken that form known by the name of coke.

The above is descriptive, not of merely laboratory experiments, but of economical processes, which are every day carried on in the conversion or analysis of coal, on a large scale. In the laboratory of nature, as well as in the crucible of the experimenter, not only these, but various other products are eliminated.

Although we have assumed that from one lump of coal, the above-mentioned results might be derived—which, indeed, would not be an extraordinary case—it will be obvious, nevertheless, that certain sorts must be more or less adapted for particular purposes, according to their composition.

At Newcastle-upon-Tyne, as well as in other colliery districts, martial pyrites are often found mixed with the coal in such abundance, as to render the latter unsaleable for fuel; but persons are employed to pick out these "brassy coals," as they are called, and remove them to a proper place where, in process of time, they become acidified and fit for the production of green vitriol.

The iron contained in the martial pyrites is in a metallic state, and combined with sulphur. The super-sulphuret of iron in this mineral, is converted into sulphate of iron at the great copperas works, by exposing the pyritical coals to the air and rain for several months in large beds prepared for the purpose. The sulphur decomposes the water which falls upon the beds, and is itself converted thereby into sulphuric acid, which combining with the iron forms the salt in question; and this is afterwards extracted

from the mass by lixiviation and crystallization.* There are several places where green vitriol is thus procured, in the neighbourhood of Newcastle; and the process is carried on upon a large scale at Deptford, near London. Beautiful natural crysta s of this salt are occasionally met with: pieces of green vitriol used to be collected in great abundance from crevices in the pillars of the deserted coal-works at Howgill, near Whitehaven: this substance is also found shooting from pyrites of iron in the vicinity of the coal in other places.

We have elsewhere adverted to the tendency of iron pyrites to originate spontaneous combustion, when mixed with bituminous coal in a comminuted state: this, however, only takes place where the mass is exposed to the free action of the atmosphere; and there seems no reason to suppose such a phenomenon occurs in the depths of the mine, where air is excluded, and the materials are in situ—though a different opinion formerly obtained. Klaproth believed that the Carlsbad waters were heated by a large bed of coal, set on fire by iron pyrites, and that iron pyrites, coal limestone, and salt springs were the raw materials out of which Nature elaborated the hot mineral waters—an hypothesis now exploded, as Jameson observes, both on geognostical and chemical grounds.

The elaboration of petroleum or mineral oil, which has been found in nearly all the countries of the globe, varying from the finest Persian naphtha, through all the gradations of the white, reddish brown, and black rock oil, to the impure earthy pitch, has been usually ascribed to some subterranean process of charring

* Parkes.

and combustion undergone by the coal in its natural deposit. There is, however, some disagreement between chemical authorities in their conclusions respecting the probable origin of naphtha—one individual discovering in its composition products indicative of destructive distillation, and another obtaining results similar to those yielded by oil of turpentine, a product of vegetable life separated at a comparatively low temperature. From a series of investigations on Persian and commercial naphthas, by Dr. Gregory, the results of which were laid before the Royal Society of Edinburgh, that gentleman concludes, that if both descriptions experimented upon were genuine, there must be at least two kinds of naphtha—one, a product of destructive distillation, the other the oil of turpentine of the pine forests of which our coal fields are formed, separated by a gentle heat, either before or after their conversion into coal. Dr. Reichenbach, who has recently succeeded in obtaining pure petroleum from coal by artificial distillation, considers that our mineral coal is nothing but the turpentine oil of the pines of former ages, which have been converted into coal. Petroleum wells he considers to be feeble distillations of large beds of coal, and produced by the universal subterranean heat of the globe.*

There are three varieties of bitumen, which appear like the rock oils in different stages of spissitude or induration:—1. Earthy bitumen, which does not occur in this country: at a place called Puy de la Lège, in France, it is so viscid that it adheres strongly to the foot of the traveller. It is found in the East, in Persia, and elsewhere, and is used for plasters as pitch is used in this country, and also as a coarse varnish.

* Jameson's Edin. Phil. Journ. 1834. p. 376.

2. Elastic bitumen, or mineral caoutchouc, so called from its resemblance to the common Indian rubber, and some of the properties of which it possesses. It is found in the Odin Mine at Castleton, Derbyshire, and in the coal mines at Montrelaie, in France, at the depth of thirty-five fathoms, where it is of a blacker brown colour than from Derbyshire. 3. Compact bitumen, or asphalt. It is found in the Palatinate, in France; at Neufchatel, in Switzerland; in large strata at Aolona, in Albania; and in large pieces on the shores, or floating on the surface of the Asphaltic Lake, in Judea, called the Dead Sea. It abounds in the islands of Barbadoes and Trinidad, in the West Indies.* In the latter, it occurs in a vast lake, three miles in circumference, called the Pitch Lake; the thickness of which is unknown. A gentle heat renders it ductile, and when mixed with grease or common pitch, it is used for paying the bottom of ships. Bitumen enters into the composition of the black indurated shales which accompany common coals: it is

* Our latest accounts of the Pitch Lake are those given by Webster in the description of his voyage; from this navigator it appears that the pitch, filling as it does, a cavity half-a-mile in length, is a dull black solid substance, breaking with an even fracture, easily scratched with a knife, and emitting a smell like coal tar. At about 310 F. it fuses into a soft mass, but does not run like common pitch—from which also, it differs in chemical composition. It is used in mending the roads at Trinidad, and for cementing stones under water; it has also been employed to obtain gas. What is most remarkable, the ground to a considerable extent in the vicinity of the lake, appears as if the contents of a pitch barrel had been mixed with the soil, and yet on it vegetation thrives luxuriantly, the pine apples grown thereon being accounted particularly good. It is curious enough that the voyager whose description is here condensed, not only seems to doubt the vegetable origin of coal, but to invert the usual theory, which ascribes the pitch lake to distillation of carbonaceous matter. It is not necessary to give the details; he, however, supposes that "the coal formations of our own country may probably have been originally in the same state as now are the pitch grounds of Trinidad," an hypothesis "which would tend considerably to explain some of the present anomalous appearances." It is added, "the pitch grounds, in my opinion, are primordials, and do not result from the conversion of vegetable matter."

also the colouring matter in certain species of limestone or black marble. Hatchetine, a black wax-like substance, occurring in the veins among the ironstone at Merthyr Tydvil, in South Wales, appears to be a peculiar species of bitumen.

Mellite, Retinasphalt, and fossil copal, are substances commonly found in connexion with bituminised wood; they have been supposed to be vegetable resins, changed by the process of mineralization, to which the latter have been subjected: or bearing a similar relation to the matter of the lignites from whence they may possibly have exuded, that the true bitumens do to the carbonaceous deposits from which they are derived, and which owe to them their different degress of inflammability.

The foregoing are substances eliquated by nature, for the most part in profound obscurity, but probably from coal seams; products, some of a similar and others of a different composition, are constantly exhibited by art. The most common of these is the coal tar of our gas-works. The manufacture of this liquid on a large scale, and with a commercial object, long preceded the idea of applying the inflammable vapour so abundantly evolved during the process, for purposes of illumination. In a work published at Frankfort in 1683, by John Joachim Becher, he says, "in Holland there is turf, and in England there are coals, neither of which are good for burning, either in apartments or smelting-houses. I have, however, discovered a method of burning both these to good coals, so that they shall not only produce no smoke or bad smell, but yield as strong a heat for melting metals as that of wood, and *throw out such flames, that a foot of coal shall make a flame ten feet long*." Here we

have not only the idea, but an actual description of the phenomenon produced by a common gas apparatus. The author proceeds :—"This I have demonstrated at the Hague with turf, and proved here in England with coals, in the presence of Mr. Boyle, by experiments made at Windsor on a large scale. It deserves to be remarked on this occasion, that as the Sweedes procure their tar from fir wood, I have procured tar from coals, which is in every thing equal to the Sweedish, and even superior to it for some purposes. I have tried it both on timber and ropes, and it has been found excellent. The King himself [Charles II.] ordered a proof of it to be made in his presence. This is a thing of very great importance to the English; and the coals, after the tar has been extracted from them, are better for use than before."*

We now come to one of the most beautiful as well as useful discoveries of modern times—the application of coal gas as a substitute for oil and candles in the illumination of streets and apartments. An expression of wonder almost necessarily escapes from the person who hears of the above experiment, and recollects, at the same time, the previously well-known phenomenon of the "burning well" at Brosely, that the artificial application of coal for such purposes should not sooner have been suggested. The tremendous exhibitions of this agent in our coal mines, were but little calculated to lead to such a result; and to this day, no economical advantage is taken of it.†

* Beckman's Hist. Inventions, vol. i. p. 339. "At present," says the translator of Beckman, in 1798, "the burning of coals in order to procure from them rock oil, used particularly by the leather manufacturers, and which on that account must not be exported, is much practised in England."

† "It appears very remarkable," observes Mr. Lyell, "that in the coal

Gaseous exhalations are common in different parts of the world—in India, Persia, China, &c. There are some of these natural gas vents in China which have been burning for centuries, and are turned to economical account. Beds of coal, though at a great depth, are frequently pierced by the borers for salt water, and from the wells thus made the inflammable vapour springs up: it sometimes appears as a jet of fire from twenty to thirty feet high, and in the neighbourhood of Thsee-Lieon-Teing, the salt-works were formerly heated and lighted by means of these fountains of fire. Bamboo pipes carry the gas from the spring to the place where it is intended to be consumed. These tubes are terminated by tubes of pipe-clay, to prevent their being burnt. A single well heats more than three hundred kettles. The fire thus obtained is said to be so exceedingly brisk, that the cauldrons are rendered useless in a few months. Other bamboos conduct the gas intended for lighting the streets and the great rooms or kitchens. Thus, Nature presents, in this place, a complete establishment of gas light. As the whole of the gas cannot be employed, the excess is conducted beyond the limits of the salt-works, and there forms three chimneys or columns of flame.*

In America, several fountains of inflammable vapour have been discovered. The village of Fredonia,

districts of the British Isles, where such a large amount of carburetted hydrogen is annually produced, means have not been adopted for making an economical use of this gas, both as respects light and heat."—*Geological Manual, p.* 152. In illustration of the circumstance alluded to by Mr. Lyell, may be mentioned the striking but unnoticed fact, that ten times as much gas is evolved annually by the waste pipe at Wallsend, described in a previous Chapter, as is manufactured by the Sheffield Gas Work's Company, for the illumination of that large town.

* Edin. Phil. Journ. 1830.

in the State of New York, is lighted by a natural discharge of gas which is collected by means of a pipe into a gasometer. The quantity obtained is about eighty cubic feet in twelve hours. It is carburetted hydrogen, and is supposed to be derived from beds of bituminous coal. The same gas is discharged in much larger quantities in the bed of a stream about a mile from the village.

The extraction of tar from pit coal was mentioned, as we have seen above, so early as the year 1683. The process was, at an after period, carried on with a commercial object in the neighbourhood of Newcastle, by a Baron Van Hacke, who died at Gateshead in 1780, having been brought over from Silesia for the purpose of managing the works at the above place. In 1781, a patent was granted to the Earl of Dundonald for "a method of extracting or making tar, pitch, essential oils, volatile alkali, mineral acids, salts, and cinders, from pit coals." So much importance was attached to this patent, that the usual term of fourteen years was afterwards extended by Act of Parliament, to twenty years, from June 1, 1785.

Here we have distillations of coal, made on the large scale, for almost every purpose, except the production of gas for illumination: to the evolution of which, all the matters regarded as of most importance by the above-mentioned projectors, are at present considered to be only subordinate. That a permanently elastic and inflammable aëriform fluid is evolved from pit-coal, appears to have been first ascertained by a Rev. Dr. Clayton, an account of whose discovery was published in the Philosophical Transactions of the Royal Society, for 1739. Subsequent chemists exhibited the gas in their experiments;

but the credit of having divulged the notion of turning it to practically useful purposes has been disputed between the partizans of Mr. Murdoch and Mr. Winsor. The former individual, while residing at Cornwall in 1792, commenced a series of experiments, in the course of which "he remarked," says Dr. Henry,* "that the gas obtained by distillation from coal, peat, wood, and other inflammable substances, burnt with great brilliancy upon being set fire to; and it occurred to him, that by confining and conducting it through tubes, it might be employed as an economical substitute for lamps and candles." In 1798, Mr. Murdoch constructed an apparatus at the Soho Foundry, in Ayrshire, which was applied during many nights to the lighting of the building; and in 1802, an illumination of the manufactory, in honour of the Peace, afforded an opportunity of making a public display of the new lights.

In the years 1803 and 1804, the general nature of gas-light illumination was exhibited by Mr. Winsor, at the Lyceum Theatre in London; but the apparatus, by the means of which he obtained the coal gas, and the mode of purification which he adopted, were kept secret. Such, however, was the brilliancy of his lights, and the publicity given to the hypothesis of illumination thus exhibited and recommended, that establishments for lighting apartments and streets with coal-gas, almost immediately followed.

It would be out of place in this work, to do more than allude to this most important product of pit coal: elaborate descriptions of the various methods of distillation, purification, conduction, and burning of

* Thompson's Chemistry.

coal-gas, adopted at the establishments throughout the country, will be found in works appropriated to the subject. Briefly, it may be stated that, in practice, bituminous coal is distilled in large closed cylindrical retorts, placed side by side in a nearly horizontal position over heating furnaces, to produce decomposition of the coal. The gross fume hence evolved by the application of heat consists, besides the carburetted hydrogen, of an aqueous* ammoniacal vapour, a thick fluid resembling tar,† and some non-inflammable gases. The separation of these products is effected by first condensing the vapour in pipes laid through a cold water-tank, and then passing it through dry quick lime, lime in solution, or red-hot cylinders, by which means the gross matter is precipitated, while the gas is carried onward in a purified state to the gasometer, from which it is distributed by service pipes for use. The best coals for gas are, generally speaking, those that yield the largest amount of bituminous products, and are at the same time, free from dirt and sulphur : some of these kinds, however, yield so spongy and worthless a description

* This liquor, on being subjected to chemical processes, is made to yield sulphate of ammonia, (the sal ammoniac of the shops); and carbonate of ammonia, (common pungent smelling salts); also Prussian blue, &c.

† In some places this product is a troublesome commodity on the hands of the makers of gas, as while it cannot be sold, the law forbids it to be poured out on account of the noisome stench which it yields : it has been known to be run into the old workings of a colliery by hogsheads at a time. It may, however, be re-distilled for gas, yielding nearly twice as much as the same weight of coals; but during the process so great a deposit of carbon takes place, that the retort presently becomes useless, and hence, it is not used. As fuel, it might be burnt under certain circumstances; its heating powers, however, according to Dr. Daubeny, are not greater than good coal. The liquid burnt in the newly invented "Naphtha Petroleum Lamps," is understood to be a distilled product of coal tar ; it is also used for effecting the solution of caoutchouc, as used in saturating the celebrated water-proof cloths; and likewise for several kinds of varnish.

of coke, that in places where the cinder is of considerable value, some sacrifice of direct productiveness in the yield of gas for the sake of superiority in the carbonaceous residuum is preferred. One pound of good coal will yield four cubic feet of gas. The coke or carbonaceous base of the coal remaining, after distillation, in the retort, varies from 25 to 50 per cent. as compared with the original amount. Coke is an important product of the gas works, and is sometimes sold for more than the original cost of the coal.

Besides the enormous amount of coal consumed for various manufacturing purposes in the same state in which the article is supplied for firing in general, there is also a vast quantity prepared and sold in the state of coke or cinders. This indeed is the condition in which the fuel is used at most of the smelting establishments, as well as for a great variety of purposes connected with the working of metals. The cinders commonly made are of two sorts—*hard cokes*, or those in which the bituminous quality has been completely exhausted; and *soft cokes*, or those which having been but partially burnt, retain some degree of inflammability: the terms hard and soft, however, as thus used, have reference rather to the methods of coking, than to the absolute quality of the products—for the hard cokes are much softer, and the soft cokes considerably harder, as the coals from which they are made partake more or less of these characteristics. The methods of preparation pursued with reference to both sorts are so accurately described by Parkes in his "Chemical Catechism," that most subsequent writers have satisfied themselves with transcribing his account.

The hard cokes are prepared by subjecting the coal

to a certain degree of torrification, in a sort of furnace called a coke-oven. Although the identical ovens described by Mr. Parkes as near Sheffield no longer exist, there are a great number of others, within a few miles of the town, from which the various manufactures are supplied, and the construction of which is exactly similar to the former. Each oven is a circular building, ten feet in diameter within, and the floor laid either with fire-brick squares, or with common brick set edgeways. The wall of the oven rises about two feet perpendicularly above the floor, and the whole is then covered with a brick arch or dome, which rises three feet six inches more, forming a cone whose base is ten feet, and whose apex is two feet, if measured within. This opening of two feet at the top, is left for the convenience of supplying the oven with coal, and to serve as a chimney during the process. The whole height of the building, from the floor, is about six feet; and the wall, which is eighteen inches in thickness, is built with good bricks, well and closely laid, that no air may get in through any part of the work.

The floor is elevated three feet above the ground, for the convenience of placing an iron barrow under the door-way to receive the coke as it is raked from the oven. When the oven is thus finished, a strong perpendicular wall of common unhewn stone is usually thrown round it, of about two feet in thickness, and carried up the whole height of the oven, forming a complete square. The four corners between the circular building and these outward walls are then filled with soil or rubbish, which is well rammed in to give greater firmness to the work, and more effectually to exclude atmospheric air. These

ovens are generally arranged six or eight in a row, either against the side of a hill, or in a mound of earth artificially raised to a level with the top, for the convenience of shooting the coals in at the aperture; the doors, or openings in front, are level with the inner floor.

When these ovens are once heated, the work goes on night and day without interruption, and without any other expense of fuel. It is conducted thus:—Small refuse coal, of good quality, is thrown in at the circular opening at the top, in quantity sufficient to fill the oven to the springing of the arch; this charge is then levelled with an iron rake, and the door-way built up with loose bricks. The heat which the oven acquires in a former operation is always sufficient of itself to light up the new charge; the combustion of which is accelerated by the atmospheric air, that rushes in through the joints of the loose bricks in the door-way. In two or three hours, the combustion gets to such a height, that the attendant finds it necessary to check the influx of the atmospheric air: the door is, therefore, now plastered up with a mixture of wet soil and sand, except the top row of bricks, which is left unplastered all night. Next morning, (when the charge has been in the oven twenty-four hours) this row is completely closed also; but the chimney remains open till the flame is gone, which is generally quite off in twelve hours more: this aperture is then covered with a few loose stones, upon which is heaped a quantity of sand or earth. All connexion with the atmosphere is now cut off, and in this condition the whole remains for twelve hours more, to complete the operation. The door-way in front is then opened, and the cokes,

which appear in large rhomboidal pieces, having a form similar to that presented by starch, are raked out into iron wheelbarrows, or low waggons, to be carted away. The whole operation takes up forty-eight hours; and as soon as the cokes are removed, the ovens are again filled with coal for another burning: about two tons are put in for each charge.* The cokes thus produced are, as just stated, very large, ponderous, extremely hard, of a light gray colour, very sonorous, and shine with a metallic lustre, appearing very different in this respect from those commonly produced by the burning of whatever description of coal under ordinary circumstances. They are used in the smelting of iron ore, in the steel casting furnaces, and in various manufactures that require an intense and long continued heat. Cokes of a similar quality are produced without the aid of ovens by piling large coals in long heaps about three feet wide, two feet high, and ten yards in length: the row being lighted by the application of burning cinders, and the access of atmospherical air regulated, and finally excluded, by covering up the mass with sand and ashes: in the conversion by this process, the fuel loses about half its weight.

When coke is required to be more of the nature of charcoal, the process is conducted in a different manner. If small coal be used, it is thrown into a large receptacle, similar to a baker's oven, built of brick, with a tall wide chimney to throw off the smoke, and previously brought to a red heat. Here the door is kept constantly open, because the heat of the oven is of itself sufficient to dissipate the bitumen of the coals, the disengagement of which is promoted by frequently

* Chemical Catechism, p. 453, edit. 1822.

stirring the coal with a long iron rake: water is also occasionally thrown upon the mass during combustion. The coke made by this method, though the same kind of coal be used, is very different from that produced by the former operation: this being intensely black, very porous, and as light as pumice-stone. It is used for a variety of purposes; but when intended for the iron and steel forges, great care must be taken that the coal shall be free from all heterogeneous mixtures, especially sulphur and pyrites.

The appearances presented by different descriptions of coal when passing into the state of coke, has already been intimated by the terms *open-burning* and *caking:* in both kinds, the process of incineration ends in yielding a residuum of ashes,—but the different effects of fire upon them are extraordinary; the pieces of coal, in the one instance, igniting and consuming, almost as independently as so many lumps of wood; and in the other, not only coagulating, but as it were, tumifying and expanding, somewhat in the manner of borax when exposed to heat. One of the free-burning coals of South Wales is remarkable for the swelling or branching which takes place during combustion, and in the process of coking, which is effected in the open air. This arborescent appearance, so different from that which takes place in other bituminous coals under similar circumstances, had led to the local term, "*Glô spagod,*" or branching coal. In some varieties (from the Clyngwernon seam, for instance,) this property exerts such an effect on the coke as to make it nearly as light and porous as wood charcoal.

In every instance where coals are burnt, there are two products evolved of a most obvious character, or

rather the same product presented under two conditions, smoke and soot,—the former, turned to no profitable account, the latter of some value in agriculture and the arts. "Were it possible," says Peckstone,* "to collect the dense smoke thrown out by burning coals, deprive it of its combustible parts, and condense it, it might perhaps be applied to the purpose of generating artificial light." This object, however, has not been attempted. Soot, derived from the combustion of pit coal, yields, according to Sir H. Davy, in addition to the charcoal which forms its basis, certain proportions of volatile salts, extractive matter, and an empeurematic oil: to these it owes its efficacy in certain cases, as a manure, being chiefly used in top-dressing some descriptions of land. It may be added, that the ashes of pit coal are used about London in admixture with clay in the making of bricks; and in the northern counties generally, as forming with the night soil, a valuable agricultural compost. Thus, we see, that not only is this fuel of inestimable value for the direct purposes of affording light and heat, but also in a variety of other ways; that even its very refuse is converted by the skill of the chemist, or the industry of the labourer, to economical and other uses.

* History of Gas Lighting, p. 40.

CHAPTER XXII.

HOME CONSUMPTION.

Extent of Home Consumption—Importance of Coal in the generation of Steam—Steam Engines—Manufactures of Earthenware and Glass—Statements of Mr. Pellatt—Gas Works—Iron Works—Consumption of Coal in Sheffield—Manchester—Birmingham—Leeds—Liverpool—London—Consumption in the United Kingdom—Tax on Coals or Hearths proposed—Waste of Coal at the Collieries.

IT would be uninteresting, if not impossible, to specify all the circumstances under which coals for the purposes of fuel are applied in this country; and while it would be an hopeless attempt to ascertain the exact quantity consumed in any given section of the United Kingdom, it were almost equally futile to pretend to estimate with precision the whole amount which may be burned in Great Britain and Ireland in the course of a year. Some details, however, in addition to what has been already stated, as being strikingly illustrative of the importance of this fuel in particular instances, may be given; and also a few of those general statements which, from the data upon which they are founded, must be acknow-

ledged to be worthy of credit: the former class of facts will shew how largely particular branches—indeed all the important branches—of our national industry are dependent upon constant supplies from those immense magazines so fortunately treasured up within our reach; and the latter may beget or increase the conviction that, comparatively inexhaustible as our mines may be considered, such proofs of an expenditure of their contents as are here exhibited, call for a vigilant prevention of all unnecessary waste.

In addition to what may be termed the direct uses of coal, which will be more particularly noticed in the present Chapter, there is an important item under the head of Home Consumption, for what might without impropriety be called an indirect use of the fuel, —namely, its expenditure in the generation of power, by converting water into vapour. This is an extremely interesting feature of the history of coal, regarded as an element in our national capabilities: and when speaking of industrial resources—of the part which, by the economical conversion of her abundant argillaceous carbonates of iron into cannon, Great Britain was enabled to take, for good or for evil, in the late wars of Europe; and of the agency of steam, in enabling us to undersell the world in our manufactures, and to grow rich, despite a national debt of eight hundred millions sterling,—when speaking on these, and similar subjects, the essential consequence of our commodious, and all but exhaustless collieries, is not always sufficiently taken into the account. At a time when such sanguine, not to say chimerical expectations are indulged, relative to steam projects, and when experiments on a splendid and expensive scale

are actually in operation, it is impossible not to regard with new interest a fossil, which, little more than a century ago, was regarded merely as an accessory to domestic comfort and convenience, but which has now not only become indispensible in our manufacturing arrangements, but is looked to as a material agent in bringing as it were nearer together, for commercial purposes, the remotest nations of the globe.

Of the aggregate power of the steam engines at present in work throughout Great Britain, we have no specific account—therefore no means of comparing accurately the consumption of fuel with the resulting effect. In 1827, the immense steam engines erected by Captain Grose, in Cornwall, were raising upwards of sixty-one millions of pounds one foot high, by the consumption of a single bushel of coal: and since then, it has been stated, that owing to the more effective working of steam, on what is termed "the expansive principle," that quantity of fuel is made to raise eighty-seven millions of pounds one foot high! That, however, is a ratio far above the average result; 55,000,000 lbs. lifted one foot high by each bushel of coals consumed, will be nearer the actual result in practice. In 1832, there were sixty-four steam engines in Cornwall, four of them the largest ever made: at that time, the consumption of coal at these engines was 84,000 bushels per month, or 2,800 per day; the effect of the steam generated by the combustion of this fuel in draining the mines, was reckoned to be equal to the work of 44,000 horses. Some estimate of the advantages derived to our inland and coast navigation, in consequence of the facility and economy with which coal is obtained for the generation of steam on board vessels, may be formed from

the fact, that in July, 1835, there were, including forty-six then building, five hundred and twenty-seven steam vessels of different sizes, belonging to ports in Great Britain. Of this number, three hundred and ninety-seven were registered of the burthen, collectively, of 36,849 tons.

Exclusive of the British iron works, which will presently be mentioned, there are two branches of our home trade, both of them of great importance, from the number of men to whom they give constant employment, and in some sort resembling each other in their object of converting materials, otherwise of small value, into rich and even precious commodities —the manufactures of earthenware and glass: both these fruitful branches of local industry owe their flourishing condition mainly to the abundance and cheapness of good coal. Pottery works are, indeed, of very ancient standing in this as in most other countries where the argillaceous earths occur; but it is only just without the memory of man, that their establishment on a splendid scale has conferred celebrity upon one of our noted coal districts. It was to the presence of appropriate fuel for the furnace, no less than to the discovery of plastic materials for the wheel, that this country has been indebted for the success of that beautiful staple which the genius of Wedgewood may be almost said to have created: and among the advantages of the pottery trade enumerated by that patriotic individual during his examination before the Privy Council in 1785, was the great number of people employed in the extensive collieries for its use. We have, however, no specific account of the quantity of coals consumed in this manufacture; though it has been stated that one of

the large ovens or kilns, in which the Staffordshire wares are baked, consumes, at a single firing, from twelve to fifteen tons of coal.

Glass makers are said to have been brought from France to this country so early as A.D. 674: but the art made little progress amongst us, previously to 1557, when a manufactory of the finer sorts was established at Crutched-Friars, in London; and a century afterwards, flint glass, considered little inferior to that imported from Venice, was made in the Savoy-House, in the Strand, and presently also at Lambeth, under the patronage of the Duke of Buckingham. As early as about 1619, the neighbourhood of excellent coal, and the discovery of its application in the making of glass, attracted this manufacture to the banks of the Tyne, where it was begun by Sir Robert Mansell, Knt. Vice-Admiral of England, and has ever since flourished. In the year 1635, King Charles, by his proclamation, prohibited the importation of any sort of glass from foreign parts, during the term granted by King James to Sir Robert Mansell, for the sole making of that commodity: in this proclamation it is set forth, that "Sir Robert Mansell had by his industry and great expense perfected that manufacture, with sea-coal or pit-coal, whereby not only the woods and timber of this kingdom are greatly preserved, but the making of all kinds of glass is established here, to the saving of much treasure at home, and the employment of great numbers of our people." The transition from the use of wood fuel to pit-coal was not effected in the glass any more than in the iron trade, without serious losses to the first adventurers, though they were not so numerous. The patentee above named, is stated

to have "melted vast sums of money in this business"—so much so, indeed, that King James is reported to have said, "that he wondered Robin Mansell, being a seaman, whereby he got so much honour, should fall from water to tamper with fire, which are two contrary elements."

Mr. Pellatt, a celebrated metropolitan glass manufacturer, informs us, that about twelve pounds weight of Newcastle coal is required to manufacture one pound of flint glass; and that when coals sold in London at about 38 shillings the chaldron, and the glass at fourteen pence a pound, the advantages of a manufacturer at the pit mouth might be about three farthings a pound over those of the London manufacturer. Contrary to what might perhaps have been expected, coal is found to be the best fuel for making the finer descriptions of glass, as wood is for the commoner kinds. The latter description of firing, which is commonly used by the French and Germans, is not known in the British glass-houses; although Mr. Pellatt says, that some years ago, when the prices of coals were very high, the terms upon which Beech logs could then have been obtained from Henley, Uxbridge, and other places, led him seriously to think about adopting the Continental method, the greatest objection to the experiment being the capital already laid out in furnaces adapted to the consumption of coal, and which would have required considerable alteration previous to the trial of wood fuel. It was stated three or four years since, that in the town of Leith, the glass-houses alone consumed 40,000 tons of coal annually! Bearing in mind the statement of Mr. Pellatt above mentioned, some conception of the immense expenditure of coals for fuel in the manu-

facture of glass, may be formed, when it is known, on the authority of official returns, that during the year 1832, one hundred glass-houses in the United Kingdom, produced upwards of 24,453 tons of glass, including the different sorts.

An important item in the consumption of coals presents itself in the manufacture of gas: a commodity formerly not known in our domestic commerce, but now produced on a large scale in most of the large and many of the smaller towns of the kingdom: of the number or extent of these gas-works we are not informed. Mr. Lowe, superintendent of two of the Chartered Gas Company's Establishments in London, once stated that the coal imported by that body alone, in the year 1830, was about 40,000 Imperial chaldrons. And in 1834, it was stated by Mr. Brand, in a lecture at the Royal Institution, that for the total supply of gas to the metropolis, there are required 200,000 chaldrons of coals, yielding 2,400,000,000 cubic feet of gas; the gas weighing 75,000,000 lbs. The light thus produced was stated to be equal to 160,000,000 lbs. of mould candles, of six to the lb.; the bulk of the coal being equal to 10,800,000 cubic feet, or 400,000 cubic yards.

The quantity of coals consumed at the various iron works in this kingdom is enormous. The quantity of iron annually manufactured in Wales has been calculated at about 270,000 tons. Of this quantity a proportion of about three-fourths is made into bars, and one-fourth sold as pigs and castings. The quantity of coal required for its manufacture on the average of the whole, including that used by engines, workmen, &c., will be about 5½ tons for each ton of iron; the annual consumption of coal by the iron

works will, therefore, be about 1,500,000 tons. The quantity used in the smelting of copper ore, imported from Cornwall, in the manufacture of tin plate, forging of iron for various purposes, and for domestic uses, may be calculated at 350,000, which makes altogether the annual consumption of coal in Wales = 1,850,000 tons. The annual quantity of iron manufactured in Great Britain is stated to be about 690,000 tons, in the working of which, if we assume the ratio furnished by Wales, there will be consumed about 5,550,000 tons of coal yearly.

It may not be uninteresting to introduce in this place, a few details relative to the sources and modes of supply at three or four principal towns. In Sheffield, besides the coal consumed in large quantities by the steam engines, gas works, and for manufacturing purposes, the steel converters and melters use a vast amount of hard and soft coke, which is mostly prepared in the manner previously described, in situations near the pits a short distance from the town. The oldest pits are in a south-eastwardly direction from the town, namely, about the Manor, the Intake, and Birley—these places being respectively at distances of two, three, and four miles. The coals are mostly carried in one-horse carts, each containing about seven corves in measure, or one ton by weight; a surprising number of these vehicles being constantly thus employed on the Park road. Considerable quantities of coal and coke have of late years been brought into the town by canal on the north side, from the collieries about Rotherham, those on Attercliffe and Tinsley commons, and still more plentifully by the self-acting waggon or tram road, previously described, from the Low Manor pit, belonging to a company who

are understood to be realising immense profits by their various coal works in the neighbourhood, leased from the Duke of Norfolk. This company alone supplies to the town 159,000 tons of coal per annum. There are some other inferior sources of supply mostly held by independent proprietors. The prices of household coal, which is generally a mixture of hard, small or *sleck*, and round or *cobblings*, is about 7s. 6d. per ton, including leading to the middle of the town; prices at the pits varying according to the distance. The strong clear hard kinds used by the anvil men, is much dearer; commonly about 15s. or 16s. per ton, when laid down: this, for the purpose of heating the steel rods forged into the various articles of Sheffield ware, is ordinarily burnt into a sort of soft black coke by the workmen, on the smithy hearth, previously to use.

The immense consumption of coal in the large manufacturing town of Manchester, is supplied,—1. from sources extending almost from the town itself to near Bolton, a distance of about eight miles;—2. from Worsley, seven or eight miles off;—3. from pits lying between Manchester and Oldham;—4. from others, between Manchester and Ashton;—5. some portion from the Rochdale side of the town;—and 6. many of the best coals from Wigan. The prices for the small and hard kinds, respectively, as delivered in Manchester, are from 6s. 8d. to 10s. and 12s. per ton. The Act of Parliament for the Manchester and Liverpool Railway, with a view to obviate the inconvenience of the smoke raised by pit *coal*, enforces the exclusive use of *coke*, which increases the expense of fuel about 40 per cent. for the use of the locomotive engines.

Birmingham is supplied with coals from Tipton, Oldbury, Bilston, West Bromwich, Wednesbury, and Dudley; the greatest quantity coming from West Bromwich, and the best qualities from Wednesbury. It is chiefly brought to the town by the Birmingham canal, though some portion is carted in by small proprietors: carts are likewise employed in distributing the commodity from the different wharfs. Manufactories are supplied at from 6s. to 10s. per ton; smiths at 17s.; and families, in general, from 9s. to 12s., according to quality.

The following interesting particulars relative to the working of the pits about Leeds, and from which the supplies of that important town are derived, have been kindly furnished by an intelligent friend, conversant with the details:—The Rev. R.H. Brandling's pits at Middleton, are three in number. 1. *Day Hole*, the entrance of which is on the side of a hill, and a subterraneous passage, of a very considerable length, is traversed, prior to the arriving at the drawing shaft. There are three qualities of coal; first, that which is called *Deep Coal*, and lies at the depth of one hundred and sixty or one hundred and seventy yards below the surface. The second quality is called *Little Coal*, which is got about forty yards below the top: these coals are not so bright as the deep coal, but they burn longer, and, consequently, are much used for engines, dye-houses, &c. The third quality is what is called, in Yorkshire, *Sleck*, being very small, and used principally for furnaces, founderies, and the hearths of black and whitesmiths, &c.—2. and 3. These are the *Venture and West Pits*; the coals from them are considered durable, but leave a quantity of white sediment or ash in burning.

These coals were first brought to Leeds under an Act of Parliament, obtained in the year 1754, and were distributed for use through the town, at the Staith, called Casson's Close, being the site upon which the South Market now stands. Another Act was obtained in 1803, and the coals are now deposited at what is called the *Old Staith,* a little nearer Hunslet and Pottery Field than the South Market. The mode of conveyance to the town was by an iron railway, formed under the above Act of Parliament; the coals were dragged along, until recently, from Middleton, by a locomotive engine, which usually drew thirty-six waggons at one time. Two men having been killed by the bursting of the engine, the coals are now brought by horse power, one horse drawing six waggons. The deep coal is sold at the Staith at 16s. per waggon, containing twenty-four corves, and warranted to weigh forty-five cwt. The little coal, in which there is a slight admixture of metallic matter, is sold at 9s. per waggon, and weighs full heavier. Sleck is sold at 6s. per waggon. Two-thirds of the coals sold are of the first of the qualities mentioned. By the Act of Parliament, Mr. Brandling is bound to deliver (if demanded,) sixty-eight waggons per diem, at the Staith in Leeds, and twelve upon Hunslet Moor; but the average number of waggon loads transmitted per diem, is from one hundred to one hundred and twenty in number.

Thorp Hall Collieries may next be mentioned. Although the soil in the neighbourhood of Thorp Hall belongs to Lady Gordon, who recently succeeded to the possession of the estates of the late Marchioness of Hertford, the coals are the property of William Fenton, Esq. There are seven or eight pits

belonging to this gentleman. The coals burn very bright and hot, but are very swiftly consumed. At Thorp Hall, as at Middleton, there are three kinds of coal, which is sold at the following rates:—The deep coal at 11s. per waggon, weighing thirty-four cwt. each; little coal at 8s. per waggon, same weight; sleck of same weight, at 5s. per waggon. Some of these pits have been open nineteen years. Thorp Hall is about two miles and a half from Leeds, on the east side of the river Aire, and the coals are brought in vessels to the Waterloo Staith near the Old Church.

Rothwell Haigh Colliery comprises three pits of the best deep coal, which is sold at two shillings per tippler—each tippler weighing about 5½ cwt. A coal of inferior quality, called *little* or *top coal,* and which is procured at a depth of one hundred yards, is sold at one shilling and four pence the tippler. The coals are sold at Crown Point Staith, being a few hundred yards nearer the Old Church than the Waterloo Staith. These coals are considered of a very superior quality, being bright, ardent, and durable. The Middleton coals are nearly of the same quality; but at Rothwell Haigh, about six inches of coal at the bottom of the bed, as it leaves in burning much sediment, is left in the ground. The principal difference betwixt the deep coal of Middleton and that of Rothwell Haigh is, that at the former place is got, along with the other coal, the six inches of inferior quality just mentioned, which causes the white sediment in burning. At the latter, this is not the case. The soil belongs to Lord Stourton, but the coals to J. and J. Charlesworth, Esqrs., who have another pit at Lofthouse, forty yards deep; and the coal of which is swift, clear, and ardent.

The coals at Beeston Park are the property of Mr. James Leather, who resides near the pits. Many of these coals are consumed at the Old Gas Works in Leeds, and are delivered in the town at about the same price as those sent from the Old Staith. The pit opens upon an elevation of considerable height, and is situated from two to three miles south-west of Leeds. The bed of coal, which consists only of one quality, lies from 112 to 144 feet below the surface. The price at the pit is 13d. per pool, weighing about 4½ cwt. A considerable quantity of these coals is consumed, but the quality is considered inferior to those supplied from Rothwell Haigh, and other places.

At Beeston also there are four pits—two in the occupation of Mr. Hill, and two in the occupation of Mr. Carter. The coals, generally, are of an inferior quality to those at Beeston Park, being softer; they are used principally for steam engines. The beds lie only about 24 to 28 yards below the surface. At the pits these coals are sold out in scoops at 3d. each; three scoops making a pool. Delivered at Leeds, the price is from 4s. 6d. to 5s. per ton. In one of the pits belonging to Mr. Carter, there is a bed of coal fit for domestic purposes, and suitable for making gas; a good deal of it is now used in dwelling-houses. It is delivered in Leeds at 7s. 6d. per ton: the pits are about two miles south-west of the town.

The coal at Manston is the property of S. W. Maud, Esq., of Selby. The colliery, which has been worked for nearly half a century, is situated about four miles east of Leeds, and is contiguous to the Leeds and Selby railway, by which conveyance, the coals raised here, and those from Mr. Gascoigne's pit, at Garforth, are conveyed to a depot recently formed

at the head of the railway station, at Marsh-lane. Since the forming of this depot, the quantity brought down to Leeds has been much increased; and large quantities are conveyed from thence to Harrogate, Wetherby, and places adjacent, and even to Selby. The coals from the two collieries just mentioned, are considered similar in quality, and are sold at the same price. The best deep coal lies about one hundred yards below the surface, and is as durable and equal as most of the coals delivered in Leeds; these coals are delivered at the depot, Marsh-lane, at 6s. 3d. per ton, or 16s. 6d. for fifty-three cwt.; at the colliery the price is 1s. per pool, weighing about four cwt.

Colton Colliery is situated about one mile from Manston; the pits have not been worked more than seven years, and are the property of Mr. Edmund Dawson, of Rothwell Haigh; the coals are somewhat inferior to those of Manston and Garforth: the best kind is found about eighty-four yards, and the second or little coal about fifty yards below the surface; the price at the pits is 10d. per pool, or 6s. 8d. for the best, and 6s. for the little coal per dozen, weighing twenty-eight cwt. There is another pit at Green Farm, belonging to the same gentleman.

The town of Liverpool is chiefly supplied with coal for home consumption from pits at Wigan, distant twenty-two miles; from St. Helen's, distant twelve miles; and from Prescot, at the distance of about eight miles. The carriage is by canal and by railway—the facilities of transit by the celebrated line between Manchester and Liverpool, having led to a considerable reduction in the price of the coal taken from Wigan to Liverpool: at one time, the price was quoted as 10s. 10d. per ton, for household coal, which

is a mixture of hard and small, and usually fluctuates between 11s. and 12s. per ton. Hard coal from 15s. to 16s. It has been contended, however, that on the whole, the price of coals by the railroad is little if at all lower than the price of the water borne commodity.

Large quantities of coal are exported from Liverpool to America: this supply is chiefly drawn from Wigan, near to which a place called Orrell, gives name and character to what is considered the best kind. Hence, "Orrell coal," among the importers in the United States, like "Wallsend" in the London market, is an epithet conferring reputation, and which, therefore, the trade imposes by consent on the better kinds of coal.

The consumption of coal in London has been variously estimated: Mr. Buddle, of Newcastle, and Mr. Horne, a Westminster coal merchant, both state it to be about a million and a half of chaldrons per year—five or six thousand chaldrons a day. H. Taylor, Esq. Agent to the Duke of Northumberland, gives the following as an analagous estimate of the consumption of coals in Great Britain:—The annual vend of coals carried coastwise from Durham and Northumberland is 3,300,000 tons; adding one-fifth more for home consumption, we have 3,960,000 tons. This quantity supplies about 5,000,000; and supposing the whole population of Great Britain to be 15,000,000, this must be trebled; for though these two-thirds of population are perhaps less able to afford fuel, yet taking into consideration the manufacturing districts, and the cheapness of coal in the interior, the estimate will not be too high at 11,880,000 tons.—This authority assigns, as the produce of our iron works, 600,000 tons; to produce which requires,

at least, four times the quantity of coal in making even pig-metal, and the extraordinary consumption in smelting the ores of the Cornish mines—3,000,000 tons. These items taken collectively give the amount consumed in Great Britain, as 14,880,000 tons; to which if we add, as exported to Ireland, 700,000 tons, the total consumption of the United Kingdom is 15,580,000 tons.

Mr. Perkins, a colliery owner of Northumberland, during his examination before the Lords' Committee in 1829, presented a table, shewing the real import of coals for each year during the twenty-eight years, commencing with 1801; also the mean annual rate of increase for two periods of fourteen years, and one of twenty-eight years; computed from the actual imports: according to which respective rates of increase a calculated import is apportioned. From this table it appears, that the real import during the years enumerated was 32,580,515 chaldrons; and the mean annual rate of increase for twenty-eight years, say from 1801 to 1828 inclusive, was 22,507 chaldrons, apportioning the entire import. The mean annual rate of increase for fourteen years, viz. from 1801 to 1814 inclusive, was 21,293 chaldrons; and the mean annual increase for the next fourteen years, viz. from 1815 to 1828 inclusive, was 32,616 chaldrons.

In 1801, the population of London and its vicinity was stated to be		818,129
The import of coals for that year...	859,738	
In 1811, the population was		953,276
The average import of ten years, ending 1811.........................	993,182	

The population increased 1.65§ per annum for the ten years.

The whole average increase of import was 15.52§.

In 1821, the population was 1,144,531
The average import of coal for 10 years, ending 1821 1,161,784
The population increased 2.33 per cent. per annum.
The whole average increase of import was 19.61 per cent.

It appears the import of coal did not in these latter ten years retain the same rateable proportion of increase as the preceding ten years:—

1.65 : 15.52 : : 2.33 : 21.91
19.61
———
2.30 abated per centage of increased import.

On the whole, Mr. Perkins assigns about nine chaldrons annually for the use of eight persons in the metropolis before the general extension of gas-works, and ten chaldrons since. In 1829, the quantity of coals imported in the port of London was 1,583,511 chaldrons 1 vat.

Certain of the northern coal owners, in order to relieve themselves of the heavy dues which encumbered sea-borne coal, at one time proposed taxing the commodity generally. Mr. Buddle recommended the alternative of two plans—taxing all collieries, or imposing a tax on every fire-place: the latter mode, reckoning 3s. per annum to be laid upon each hearth, would, he calculated, produce about a million a-year. Captain Cochrane, of Hetton Colliery, recommended a repeal of the duty, and in lieu thereof the imposition of 1s. a ton on all coals consumed over Great Britain, which he believed amounts to 15,000,000 of chaldrons, which would increase the revenue at least £100,000 annually; moreover, it would, he contended, "give additional employment to 375 sail of vessels of 180 tons burthen, 300 sailors, and 6,000 colliers; besides the increase of men which the ma-

nufactories benefited by such a measure would naturally require."

It may not be improper, in closing this Chapter, to advert to what may be regarded as an important item in the home consumption of our coal,—namely, its *waste*. Those who have not paid some attention to the subject, will probably be but little prepared to learn how large a quantity of this valuable commodity has been constantly destroyed, in one way or other, instead of being sent to market. The value of the article thus profitlessly abstracted from the common stock of our national fuel, depends in part upon its quality in the mine, and in part also upon the price it would fetch either alone, or as mixed with the better sorts of coal.

The Staffordshire collieries produce abundantly a soft sort of coal, considered by Dr. Thompson to be of the same species with the cherry coal, of a velvet-black appearance, which constitutes the greater part of the upper seams of the Glasgow fields, and which is so abundant in Fifeshire. He adds, that in the coal fields on the north, and north-west of Birmingham, the loss in mining, owing to the tender nature of the substance itself, and the comparatively trifling demand for small coal, amounts to about *two-thirds of the entire seam!* In allusion to this statement, and the efforts of a celebrated philosopher to economize the application of fuel, Mr. Tredgold exclaims, "the waste, which Count Rumford lamented so much, dwindles to nothing, in comparison with the wholesale destruction of a valuable material. Are you a manufacturer? Look around, and see what generates the power which enables you to compete with other nations. Are you a philanthropist? Consider that a

substance is destroyed, which would add comfort to millions of your fellow-creatures: consider the risk at which it is procured, the number of lives that are lost by explosions, and the misery these catastrophies create—surely, some means of rendering that portion useful, which is now wasted, may be devised!"*

A still more lamentable waste of excellent coal takes place in the South Welsh, and more particularly in the northern collieries, at the pit mouth, in consequence of the practice of screening, described in a former Chapter. This is done to meet the taste for round coals so generally prevalent in the metropolis, and also to meet the circumstances of a demand which, before the trade imposts were reduced, and weight substituted for measure, required the coals to be shipped of a large size, however they might be comminuted before reaching the consumer's cellar. In 1829, Mr. Buddle stated before a Committee of the House of Commons, that, taking the small coal which was not worth bringing to bank, and that which was produced in rendering the remainder merchantable together, the waste was from one-fourth to one-third of the whole. Of this amount, a trifling proportion is used by the colliers, who have grates adapted for burning it, and a little is sold, at about one-tenth of the price of the screened coal: the remainder is carted away to mend the roads; or, as a more ready method of getting rid of it, is consumed near the spot where it has been produced: at one colliery as many as from ninety to one hundred chaldrons a day have been destroyed.

* Annals of Philosophy, vol. viii. p. 169.

CHAPTER XXIII.

FOREIGN COAL TRADE.

Early Notices of Exportation of Coal—During the Reigns of Henry VIII. and Queen Elizabeth—Charles the First—Act of Trade, 1663*—Lord North's Reasons for taxing the Coal Trade to Foreign Ports—Produce of our Coal Fields essentially different from that of our Manufactories—Considerations relative to Free Trade—Politic Objections to an unrestricted Foreign Vend—Opinions of Mr. Brandling and Mr. Buddle—Professor Sedgwick and Dr. Buckland—Scale of Duties on Coals imported, in* 1831*—Reduced in* 1834*—Duties on Coals sent abroad abolished in* 1835*—Impost levied on Coals at Foreign Ports—Remarks on the Policy of the Duties in the Ports of France.*

As might naturally be expected, the earliest notices of the exportation of coal from this country, occur in the records of Newcastle-upon-Tyne, and in the Royal Proclamations and other State Papers relative to that town. The first mention of the subject directly is in the rolls of Parliament, A.D. 1325, 19 Ed. II., at which time, as we have already seen, a vessel, the property of one Thomas Rente, of Pontoise, a town

in the ancient dominions of the Kings of England in France, is mentioned as trading to Newcastle-upon-Tyne with corn, and returning with a freight of sea-coals. Between that and the next notice which occurs of the exportation of coals, there is an interval of nearly two hundred years, during which period, however, there is every reason to suppose coals were exported, though whither or in what quantities we have no information. In 1546, orders were sent from the King (Henry VIII.) to the Mayor of Newcastle, to forward, with all possible despatch, three thousand chaldrons of coals to Bullein, in France. This was a large shipment; and the trade to France so increased as soon after to be petitioned against, though on what ground does not appear; and in the Journals of the House of Commons, Feb. 1, 1563, mention occurs of a bill to restrain the carriage of Newcastle coals over sea: in July of the same year, an Act was passed in Scotland to prevent the exportation of coal, which had caused a great dearth of fuel in that country. In the year 1600, a patent of Queen Elizabeth, appointing a collector of customs, &c. at Newcastle, recognises the existence of an old imposition of 5s. per chaldron on coals exported beyond sea, which may have been laid on at the time of passing the above-mentioned Act. Toward the end of the reign of this Princess, the home trade had so increased, that the duty of 4d. per chaldron produced £10,000 a year.

A small tract published in 1615, and entitled "The Trade's Increase,"* informs us that, "besides our own ships, hither, even to the mine's mouth, come all our neighbouring nations with their own

* Cited in Anderson's Dict. Commerce, vol. i. p. 494.

ships continually, employing their own shipping and mariners." The French, who, for obvious reasons, would be early and considerable customers, are represented at this time, as trading to Newcastle for coal in fleets of fifty sail at once, serving the ports of Picardy, Normandy, Bretagne, &c., as far as Rochel and Bourdeaux; while the ships of Bremen, Embden, Holland, and Zealand, were supplying the inhabitants of Flanders with the same commodity. This foreign vend appears to have raised the price of coals to the home consumer, and thus to have occasioned some complaints. In 1616, it appears that 13,675 tons of coals were shipped from Newcastle.

It has before been intimated, that the collieries in the north were among the weapons wielded between Charles the First and his Parliament: it may be added, that there is still extant* a curious letter from the King to the Marquis of Newcastle, written in figure cyphers from Oxford Nov. 2, 1643, concerning the procuring of arms from Holland in exchange for coals; and at the beginning of the year following, "at a court of the hostmen of Newcastle, it was ordered that six brethren of that Society should attend the Mayor, to adjust such quantities of coals as should be *lent* to his Majesty to procure corn, powder, and ammunition, for the King's service, pursuant to a commission from the Marquis of Newcastle."†

It was provided by the Act for Trade, 1663, 15 Car. II., that "coals transported in English shipping and navigation for his Majesty's plantations, in lieu of all custom, shall pay only for one chaldron of Newcastle measure, one shilling and eightpence;

* Rushworth's Collections, part iii., vol. iii., p. 368.

† Brand's Newcastle, vol. ii., p. 286.

for one chaldron of London measure one shilling, provided good security be given for landing the said coals accordingly."* By an Act passed in 1759, 32 Geo. II., an additional duty was laid on coals exported: five years afterwards, it appears that 365 vessels—one for every day in the year—laden with coals, cleared out of the Tyne for foreign ports—a greater number than had previously been known: nearly the same number cleared out in 1772.

From the foregoing statements, it will be seen, that from a very early period in the history of our northern collieries, an over sea trade has been carried on between the port of Newcastle and different foreign countries, and which description of traffic has of late years extended itself to other British ports, particularly London, Swansea, Liverpool, Whitehaven, Sunderland, Hull, Borrowstoness, Greenock, and upwards of thirty other places. The quantities shipped foreign in 1834, from the eight ports just named, being for the highest, namely, Sunderland, 94,314 tons; and for the lowest, namely, Hull, 12,096 tons; Newcastle, in the same year, exporting nearly 140,000 tons.

It would have been as tedious to have detailed the numerous fiscal regulations under which each successive Government has allowed this branch of commerce to be carried on, as it would probably be impossible to recognise in every case, the grounds upon which the imposts have been laid or modified. Lord North thought it a good reason for proposing an increase of duty on the foreign trade during his administration, that our enemies ought not to be allowed to burn our coals as cheaply as ourselves; but that reason ceased to influence the Cabinet, the moment that the Minis-

* Molloy de Jure maritimo.

ter was convinced by the coal owners, that such a course, instead of increasing, would diminish the revenue.

It will hardly be doubted, by any class of the community, except, perhaps, some of the exporters themselves, that coal shipped for foreign consumption, admitting that it ought to be exported at all, is a most legitimate commodity for taxation; nor will it probably be denied, even by the stoutest advocates for free trade, that coal, as a species of merchandise, differs essentially from agricultural produce, or manufactured goods. In reference to the latter point in particular, it may be affirmed that, so long as we can command

"But man and coal, the craftsman and his fires,"

the manufacturing skill and industry of Great Britain may sustain her claim to precedence in the market of the world,—even while she draws many of the materials of this pre-eminence from other countries. And with respect to those productions of the earth which are requisite for the sustenance of man, these it is well known may be raised, almost *ad libitum*, so long as fertility can be maintained. Coal, on the other hand, being incapable of reproduction or increase, it follows that whatever force several arguments for or against a free trade in grain or manufactured articles may have, they do not legitimately apply to the commodity in question. It might be urged that the exhaustion of our lead and tin mines by foreign traffic in their produce, should be reprobated on the same grounds—and with propriety, could it at the same time be shewn, that these metals are as essential as coal to our domestic comfort and manufacturing prosperity.

The reasons urged by coal owners before the Parliamentary Committees of 1829, in favour of a mitigation of the export duties, were,—first, the employment of British ships and seamen; second, that it would give us the controul of the countries whose manufactures were dependent on the supply; and, third, that the foreign vend would be overplus amount of the home consumption. It is not necessary to advert particularly to the first reason, as if admitted at all it would prove too much, namely, that the navigation of British bottoms, richly laden with export merchandize, is, as an exercise of seamanship merely, and without reference to the nature of the commodity carried, of paramount importance. With reference to the second reason, the Lords' Committee put the following question to Mr. Buddle:—"Are you of opinion that a high duty upon the export of coal to foreign parts has a direct tendency to encourage the collieries in those countries?" To this the examinee replied, "I have always considered it as amounting to a bounty on foreign coal to encourage the foreign mine adventurer." Again: "Suppose we were in the habit largely of supplying any particular country with coal, do you imagine that that would in a great measure place their manufactures at our mercy?" The same witness replied, "I should think undoubtedly so. I would beg to observe, that the sugar refinery business in Russia is almost exclusively carried on by the small coal exported from this country. It must be obvious, therefore, that if any thing should occur to interrupt our dealings with Russia, and that our coal was withdrawn, being, as we understand, the cheapest fuel they can obtain, it would greatly enhance the expense of that particular manufacture in

Russia. I should therefore say, that this branch of manufacture in Russia is mainly dependent on the supply of English coal of the above description." This statement, admitting its meaning to the fullest extent, is still much too confined in its bearing to lend any force to the general argument in favour of exportation: nor does it fairly sustain the doctrine assumed by the question of the Committee.

We have already seen that the Dutch Government have burthened the importation of coals with a prohibitive duty—something like a guinea per imperial chaldron. Now, since the Dutch impose so high a duty as that, for the sake of protecting their own collieries, would they not on the same principle, it is reasonably asked, add to that duty the amount of whatever might be taken off at our ports? To this Mr. Buddle replies, "If it is the policy of the Dutch Government to exclude British coal, I should conceive that whatever duty the British Government were to take off, the Dutch Government would lay on: with regard to them, no alteration, in my opinion, could affect our trade; for it appears their policy is that of exclusion. I would not, therefore, look to any relief from the Dutch Government, or from exportation to Holland. Where I should look for relief is to the North of Germany, and to Russia." On the next question—"Supposing such trade was opened as described, is there any fear of the exhaustion of our mines?" Mr. Buddle remarks, "I would beg leave to observe, that I think the point which the Legislature ought to attend to is, if possible, to draw such a line as would give foreigners the mere redundancy of our mines; that is, that we might not commit public waste by the destruction of the de-

scription of coal we can get no market for. I should say that the object would be to manufacture a coal fit for the home market, and then see what is the residue from such manufacture, and to consider what is the best market and the best way of disposing of it, so as to produce the greatest revenue to Government, and to pay the mine owner." So far as foreign sale could be made of small coal, which is at present wasted, the alteration would, of course, be one of advantage to all parties; but the relief sought by the coal owners at large was of a more extended nature. "What the coal owners ask in the first instance, and to which," says Mr. Brandling, an affluent individual of their body, "I conceive they are fairly entitled, is a gradual reduction and abolition of duties both export and home, that the coals may be put upon the same footing with all other articles of produce of English industry from English property. If that cannot be accomplished, an equalization of the export duties with the home duties, an equalization of the duties upon the inland and seaborne coals, so that they may be in the same market with the same duties, and a removal of all the impediments to a free exercise of our trade." Now, it is precisely because coals, as to the nature of their production, and notwithstanding the application of the term "manufacture," do appear to differ so essentially from other articles produced by English industry from English property, that sound policy seems to require that some impediment should be placed in the way of a free exercise of the over-sea trade in coals.

It will be remembered that the answer of Mr. Buddle, before cited, has no reference to the question by which it was elicited, namely, the possible ex-

haustion of our mines; nor does the voluminous evidence taken before the Committee of the House of Lords contain hardly a single allusion to the subject, though, as we shall presently see, it was otherwise in the examinations in the Commons. "I have not the smallest doubt that the generality of the inhabitants of Great Britain believe that our coal mines are inexhaustible, and the general conduct of the nation, so far as relates to this subject, seems to imply that the inexhaustibility of our coals is universally held as an established fact. The conduct of the public says so in plain enough language. If it was not a generally received opinion, would the rage for transporting coals be allowed to go on without limitation or remorse? But it is full time that the public were undeceived in a matter which so nearly concerns the welfare of this flourishing island." Thus wrote the author of the "Natural History of the Mineral Kingdom" nearly fifty years ago: this, indeed, is but a specimen of the staple of his complaint, which is drawn out to a considerable length, and frequently in terms calculated to force a smile, notwithstanding the grave corroborative testimony of the learned Professor Buckland, recently delivered before a Committee of the House of Commons. It is consolatory, however, that even the last-named authority has placed in a remote era the consummation anticipated by Mr. Williams in the following paragraph:—"The present rage for exporting coals to other nations may aptly be compared to a careless spendthrift, who wastes all his youth, and then heavily drags on a wretched life to miserable old age, and leaves nothing for his heirs. When our coal mines are exhausted, the prosperity and glory of this flourishing and for-

tunate island is at an end. Our cities and great towns must then become ruinous heaps for want of fuel, and our mines and manufactories must fail from the same cause, and consequently our commerce must likewise fail. In short, the commerce, wealth, importance, glory, and happiness of Great Britain will decay and gradually dwindle away to nothing, in proportion as our coal and other mines fail: and the future inhabitants of this island must live, like its first inhabitants, by fishing and hunting."

Our author, indeed, somewhat mitigates the severity of his sentence upon those inhabitants of London and the south-east coast, who may be unhappy enough to witness the exhaustion of the coal about Newcastle, by the consideration, that "there is a pretty good fund of coal in Fife, and other places upon both sides of the Frith of Forth, which may be sent to the metropolis and to other places." Ireland, too, is consoled, by reference to another Scotch treasury, though the allusion is couched in terms evidently untempered by any recollection of the exhaustless peat mosses of the Emerald Isle. "The city of Dublin," says Mr. Williams, "and many other parts of Ireland, depend upon Great Britain for a necessary supply of coals, even for culinary uses; and, I hinted before, that the collieries of Whitehaven, from whence Dublin is chiefly supplied, are already very deep. However, there is a valuable and extensive magazine of coal for Irish consumption treasured up in the county of Ayr; and it is well for Dublin, and other parts of Ireland, that there are such magazines in Ayrshire and the north-west of England; and what would become of Dublin, &c. were these coals to fail? In that event, it might be

said with propriety, that the Irish volunteers would blow a cold coal. They little think of this when they begin to swagger, disturb the peace, and neglect their proper occupations. They little think that Britain can starve them, knock up many of their manufactories, and ruin their cities for want for fuel."

Such were the apprehensions, and such the style, of an ingenious but verbose writer on the coal trade half a century ago. While, however, we may be allowed to smile at the manifestation of such quaint patriotism, it must at the same time be confessed that the subject is really one of great importance in a national point of view.

In the examination before the Committee of the House of Commons above referred to, Professor Sedgwick expressed himself as not being prepared to answer the question as to the expediency of exporting coals: he conceives, however, that the best beds in the Newcastle field are not likely, at the present rate of consumption, to last above 350 or 400 years. Dr. Buckland, of Oxford, makes an estimate nearly similar. The latter eminent geologist seems to recognise the distinction above contended for as existing between coal and other descriptions of produce, whether agricultural or manufacturing: few countries are so sterile but they may be made to yield, according to their cultivation, some of the fruits of the earth; and still fewer are they where, under determined or compulsory circumstances, the more artificial wants of life may not be to some extent produced; but an absolute prohibition of the export of coal from this country, could not have the slightest tendency to encourage the working of mines abroad where the fossil does not already exist. In the Ne-

therlands, there is a very extensive field of coal, which is largely worked; and as that is one of our most convenient export countries, the question arises, whether any vacuum created in the current vend by a prohibitory enactment, would not naturally be filled up by additional working in their own mine? Undoubtedly it would; and thus, says Dr. Buckland, "lead to the more rapid exhaustion of that mine," and consequently, it is rejoined, to the encouragement of coal mines abroad. The learned Doctor rebuts the force of this inference. "If," says he, "encouragement could cause the production of beds of coal as of annual crops of corn, it would be so; but as nature has limited the quantity of coal, and any reproduction of it is impossible, if you increase the consumption, the total exhaustion will of course be accelerated." As to the inquiry, whether it be probable that there may be a sufficient quantity of coal in the districts abroad to meet the demand for the foreign manufacturer in the foreign market, the examinant appeals to the case of France, and attributes the comparative absence of manufactures in that country to the deficiency of coal. It is remarkable, that the Netherlander exports coals to America, while France, which is close at hand, and wants them for her manufacturers, does not take them: the reason assigned for this apparent anomaly is, that the carriage to America is water carriage, and often back carriage, while the carrying over France is chiefly land carriage. The policy of permitting the exportation of coals to foreign parts from Newcastle, is, in the opinion of the competent authority above quoted, "permitting foreigners to consume the vitals of our own posterity. I consider," says he, "coals the sta-

mina upon which the manufacturing prosperity of the country primarily depends; and I think it our duty not to spare one ounce of coals to any person but ourselves."

By the Act of 1831, the following duties were imposed upon the exportation of coals, culm, and cinders, in lieu of those theretofore payable:—Coals, not being small coals, exported to any place, not being a *British* possession; *videlicet,*—

	£.	s.	d.
In a British ship, the ton............	0	3	4
In a ship not British, the ton	0	6	8

Small coals, culm, and cinders exported to any place not being a *British* possession; *videlicet,*—

	£.	s.	d.
In a British ship, the ton............	0	2	0
In a ship not British, the ton	0	4	0

No coals to be deemed "small coals" for the purposes of this Act, except such as shall have been screened in the manner directed by the Act 56 Geo. III. cap. 127, that such as will pass through a $\frac{3}{8}$-of-an-inch screen.

By a return to Parliament, it appears that during the year ending 5th January 1833, the following amount of coals had been exported from the United Kingdom to different ports of the Mediterranean, namely—to Gibraltar, 10,161 tons; to Spain and the Ballearic Islands, 605 tons; to Malta, 3,422 tons; to Italy and the Italian Islands, 4,039 tons; to the Ionian Islands, 1,180 tons; to the Russian ports in the Black Sea, 2,435 tons; to Turkey and Continental Greece, 323 tons; to the Morea and the Greek Islands, 647 tons; to Egypt, 7,260 tons*;—total,

* It was remarked during the discussions on the Coal Trade in 1831, that owing to the enormous amount of duties which accumulated upon the com-

30,072 tons. In 1834, the rates of duty were still further reduced: from the 6th of August, instead of the above-noted imposts of 3s. 4d. and 2s. per ton, an ad valorem charge of 10 per cent. was levied: and in lieu of the other two items of 6s. 8d. and 4s. per ton, an uniform rate of 4s. per ton was imposed.

The total quantity of coals, cinders, and culm exported from the United Kingdom to foreign countries in 1834, was 615,255 tons: it was distributed to the following places, in the proportions indicated by the figures:—

	Tons.		Tons.
Russia	35,214	Other parts of Africa	6,738
Sweden	11,658	East Indies and China	5,379
Norway	3,573	New South Wales, Van Dieman's Land, and Swan River	21
Denmark	72,186	British and North American Colonies	55,201
Prussia	23,787	British West Indies	43,617
Germany	50,258	Foreign West Indies	845
Holland	94,447	Unit. States of America	39,855
Belgium	270	Mexico	5
France	59,690	Columbia	54
Portugal, Azores, and Madeira	13,714	Brazil	1,637
Spain and the Canaries	1,583	States of the Rio de la Plata	966
Gibraltar	5,856	Chili	170
Italy	12,587	Peru	118
Malta	7,715	Isles of Guernsey, Jersey, Alderney, and Man	63,182
Ionian Islands	1,250		
Turkey and Continental Greece	1,329		
Morea and Greek Islands	1,471		
Cape of Good Hope	879		

Of the total amount above stated, 3,654 tons were cinders, of which nearly one-third went to Denmark:

modity between its delivery at the northern mines and its consumption in the metropolis, Newcastle coals were actually sold cheaper in Grand Cairo than in London. As an instance of the distance to which this valuable fuel is carried, Captain Head mentions that the coals used at Buenos Ayres come from Newcastle!

there was also 1,845 tons of culm, the whole of which, with the exception of a trifling fraction, was for the use of the Norman Isles last named on the foregoing list. The amount of duties received on the whole 615,255 tons, was £34,902 10s. 2d.

The northern coal owners continuing to complain, and Government being anxious to afford them relief, the Chancellor of the Exchequer, on announcing the contents of his Budget in the spring of 1835, proposed to remit altogether the duties on coals, cinders, and culm exported. This was accordingly done; and at present there is no impost on coals exported to foreign countries from Great Britain in our own ships. Vessels from Russia and Holland, as States not recognising the reciprocity treaties, pay 4s. per ton on all kinds. The policy of thus facilitating the conveyance, to any extent, of so essential an article as coal, and with no object but that of relieving the mine owners, must be very doubtful.

While, however, we send our coals to other countries thus freely, our customers in many instances tax the admission of the commodity into their ports. The imposts levied by the Swedish Government on coals imported from Great Britain, comprise duty of customs, convoy duty, and town dues, amounting together to 12s. 2d. sterling on the Newcastle chaldron, or about 50 per cent. on the prime cost. These charges are ostensibly imposed to favour a certain coal mine at Hoganäs, in Scania.

The duties paid on the importation of coals from this country into the kingdom of Denmark, are £2 18s. 10d. upon one keel of 8 Newcastle chaldrons, or 20 tons of Scotch coals.

The largest amount of coals exported from the

United Kingdom to any one place, is to Holland: the terms upon which they were admitted in 1834, are stated below*, in the official note of the British Minister, transmitted in reply to a Parliamentary inquiry ordered by the House of Commons in that year, and pending the reduction of the foreign duties.

In reply to an order made by the House of Commons, in May 1834, for returns from Copenhagen, Hamburgh, and Rotterdam, of the number and names of British vessels entering those ports laden with coals, Consul Macgregor prefaced his despatch to Sir George Shee, with the following statement relative to 1833:—"It would appear from these returns, that fifty British ships, of the burthen of 9,740 tons, with 431 men, were employed in the coal trade to Copenhagen last year [1833], and that the quantities imported there have amounted to 2,381 tons and 4,261 chaldrons, forming an aggregate of 13,098¾ tons weight of coals." Mr. Macgregor adds, that on an average, during the years 1831, 1832, and 1833, not fewer than 308 British, and 189 foreign vessels were employed to the Baltic during each of those years: and, moreover, that the importation at Copenhagen

* HOLLAND. La Haye, le 19 May, 1834.

Monsieur,—En réponse à votre office du 5 du courant, j'ai l'honneur de porter à votre connaissance que la roi du 8 Juin 1831 (Journal Officiel, No. 15) a fixé les droits d'entrée sur le charbon de terre à deux florins per millier delivres des Pays Bas, sans distinction d'origin, et pour tous Pavillons Etrangers.

En conséquence, le charbon de terre de la Roer, importé per eau, est assujetté à ce droit, aussi bien que celui arrivant par mer d'Angleterre, d'Ecosse ou d'Irlande: l'importation sur navires des Pays Bas est franche des droits; ceux de cortie se montent à dix cents, et les droits de transit à un florin, également par millier de livres des Pays Bas.

Je saisis, &c.

(Signé) H. DE ZUYLEN DE NYEVELT.

A M. Jerningham, Chargé d'Affaires
de sa Majesté Britannique.

averaged 134 tons weight of coals to every 100 tons of shipping: "the total amount of coals annually imported into the Baltic may be estimated, according to that computation, at about 110,000 tons, being nearly one-half of the quantity exported by Great Britain to foreign countries." No duties whatever are levied in the ports of Russia upon coals imported from the United Kingdom; indeed, so necessary is it considered to give every facility to the importation of that article, that it is allowed to be landed any where without a previous inspection at the Custom-house, a form to which all other articles exempted from duty are subjected. From the year 1825 to the end of 1831, the duties with which coals were taxed on entering the Prussian States, amounted, in the eastern provinces, to 3½ dollars per zentner, or cwt.; and in the western, to 1⅚ dollars. Since 1832, and at present, 1½ dollars per cwt. is levied throughout. In the last-mentioned year, the importation to the Baltic was 603,465 cwts.; to other places, 454,115, making a total of 1,057,580 cwts.

In Portugal, the duties of 15 per cent. paid upon coals imported from Great Britain into the port of Lisbon, are levied upon valuations put upon them by the Custom-house authorities, which vary according to the market price. These duties are charged on a measure termed a *pipa*, which is equal to 3½ tons of 20 cwts. each. There are no coals imported but from Great Britain. Coals are admitted duty free into all the ports of the kingdom of the two Sicilies. There is a duty levied in the ports of France upon coals imported from the United Kingdom, of 1 franc, 10 centimes per 100 kilogrammes, which amounts to 11 francs, or about 10 shillings per ton.

A great deal has been said about the impolicy, on the part of the French, in taxing the importation of foreign coals: it is not intended in this place to give any opinion, but merely to state that the reasons offered by the late Minister of Commerce in France, as a justification of the duty, are the following:—"Coal," says he, "is very abundant in our country; and at the place of its production is sold as cheap as in any other country in the world. At St. Etienne, the cost of extracting coal is quite as low as in Wales. The cause of the high price to consumers is not, therefore, the greater expense incurred in working our mines, but in the cost of carriage. That which may be purchased for forty centimes at St. Etienne, costs three to four francs at Rouen, and four to five francs at Bordeaux. Since, then, the cause of the dearness does not proceed from the poverty of the mines, nor the inability of the workmen, but is owing to the insufficiency of works on the surface of our soil for making easy the communications between one part of the country and another, it would be the height of injustice to sacrifice the class of producers by a reduction of the duty, which, if removed to the extent of one third only, would occasion such an importation from England as would ruin our finest establishments."

"Is it not," says a recent authority,* "a sufficient answer to this argument, if we enquire what it is which principally causes the means of transport in France to be so imperfect and expensive? Whether it be not principally, if not entirely, the high prices of coal and iron which deter from the formation of canals and railroads? The very example cited by

* Companion to the Almanack, 1835.

the Minister as a justification of his system, sufficiently proves of how much greater benefit it must be to admit foreign raw materials, which would have so important an effect upon the entire industry of the country, than it is to extend at the general expense, just that amount of protection to a few capitalists which enables them to draw a scanty and precarious return for their unnatural investments." "Coal," says the Minister of Commerce, "was worth five or seven francs at Mulhausen; since the opening of the canal from the Rhone to the Rhine, the article is worth only three francs, fifty centimes, and will be further reduced to two francs, fifty centimes, when the proposed communications with Epinac shall be completed."

In this point of view, "the duties imposed on the importation of foreign coals and iron assume," says the advocate for free trade quoted above, "the form of a tax levied upon the commercial and manufacturing interests of France, for the very purpose of retarding the march of internal improvement. These duties are, besides, partial and unjust, inasmuch as they operate peculiarly in the parts of France where the coal and iron of native production are the dearest. Except at those parts, the excessive cost of transport which the Minister brings forward to excuse the existing system, would operate as an extensive protection to the coal mines and iron masters of the interior, where English coal and iron could no more compete with them, than they could now compete in the parts with the freely admitted products of England."

CHAPTER XXIV.

PROBABLE DURATION OF OUR COAL.

Difficult to assign the consumption of Coal for future periods—Estimate of the quantity remaining unwrought in Durham and Northumberland—Statements of Mr. Taylor and Professor Sedgwick—Decay of the Northern Mines will probably transfer the London Coal trade to Scotland and South Wales—Quantity of workable Coal probably over-rated—Opinions of Dr. Thomson and Mr. Bakewell, relative to the duration of the Northern Collieries.

THE prospective exhaustion, at some remote period, of the valuable contents of the various coal fields of Great Britain, and the probable consequences of such an event, have given rise to a variety of calculations and predictions; some of the latter, as we have already seen, sufficiently amusing. While, however, it is manifestly inconclusive, to estimate according to present demand the consumption of coals for centuries to come; and still more so to assign any specific condition of society to such a remote period; we are warranted, in the first place, in assuming, that the demand for this species of fuel will not diminish but increase, with every imaginable condition of the

progress of society; and, secondly, we have before us the undoubted fact, that our mines are not inexhaustible. In addition to this, there is the most direct evidence to show how far some of the most valuable beds in the northern coal fields have been worked out already; at the same time, that tolerably satisfactory calculations have been made as to the quantity remaining unwrought.

The following is an estimate of the extent and produce of the Durham and Northumberland coal fields, compiled by H. Taylor, Esq., colliery agent to the Duke of Northumberland, and himself a coal owner in the latter county :—

		Sq. Miles.
DURHAM. From South Shields southward to Castle Eden, twenty-one miles, thence westward to West Auckland, thirty-two miles, north-east from West Auckland to Eltringham, thirty-three miles, and thence to Shields, twenty-two miles, being an extent of area of		594
NORTHUMBERLAND. From Shields northwards, by an average breadth of nine miles, ...		243
		837
Portion excavated. In Durham—On the Tyne, say,	39	
On the Wear,......	40	
	79	
In Northumberland, say thirteen miles by two, ...	26	
	—	105
		732

	Tons.
Estimating the workable coal strata at an average thickness of twelve feet, the contents of one square mile will be 12,390,000 tons, and of 732 square miles, ...	9,069,480,000
Deduct one-third part for loss by small coal, interceptions by dykes, and other interruptions,	3,023,160,000
Remainder,........................	6,046,320,000

This remainder is, according to Mr. Taylor, adequate to supply the present vend from Newcastle, Sunderland, Hartley, Blyth, and Stockton, of 3,500,000 tons, for a period of 1,727 years. In the opinion of Professor Sedgwick, however, this amount must be exaggerated about one-half, in consequence of the existence of certain sterile tracts, which the calculation assumes to contain the average deposit of coal. "The best information I have," says the learned Professor, "gives a rich portion of the coal field, extending from the neighbourhood of Chester-le-Street, down the country near West Auckland; and the richest portion of that field, as far as it is at present known by actual workings, is between the Wear and the escarpment of the magnesian limestone; and I have reason to believe, partly upon a few observations of my own, but mainly upon information obtained from others, that none of the best beds of the Wear district, excepting the lowest, the Hutton seam, are found much to the west of the Wear; on the west side of that river the Hutton seam is covered by only a small number of coal measures; the coal is brittle, and lies at a comparatively small depth, but is said to be of good quality; it therefore appears that the rich part of this division of the coal field is confined in that narrow zone extending between the Wear, to the escarpment of the magnesian limestone.

"On this question I have recently obtained more full information from a gentleman, with whom I formerly examined a portion of the district: he states that 'there are five good workable seams of coal in the Wear district, between the outcrop of the magnesian lime and the east side of the Wear, extending from the neighbourhood of Chester-le-Street to Bishop

Auckland; in this district, the five good seams that may be expected are the following:—Five Quarter, average thickness four feet; the High Main, six feet; the Maudlin, five and a half; the Low Main, four; the Hutton, six feet;—that of those five, the High Main, Low Main, and Hutton are those on the existence of which you might perhaps speculate with the greatest confidence; that the High Main and the Hutton are the most certain to *prove true;* that in making the calculation of the quantity of coal still to be worked in the above district, it might be reasonably supposed, that three out of the five seams (together averaging in thickness of good fire coal about thirteen feet) might be worth working at the present time; and that a fourth may be worked hereafter, when the best seams are exhausted.' The writer states, that he is not acquainted with any colliery where all the five seams are worth working at present, or likely to become so: one or two of them are always found defective in thickness or quality."

Such are the considerations affecting the east side of the Wear; "on the west side," the Professor proceeds, "the Five Quarter coal has generally cropped out; and the High Main, Maudlin and Low Main, if not out, are often so near the surface as to be good for nothing. The Five Quarter breaks out in a ravine below Auckland Castle, and the High Main is probably too near the surface to the west of that spot to be good for any thing. The writer of the letter adds:—'I have understood that the working seams in most of the small collieries on the west of the Wear, are supposed to be the Hutton seam; the coal those collieries produce is of an excellent quality, but tender, and looks as if it came from the Hutton.' Taking

those circumstances into consideration, he does not think we can fairly calculate upon more than one seam on the west side of the Wear, within the above northern and southern limits; and he states the probable thickness to be four feet nine inches of good coal. He adds, 'there is good coal to the south and south-west of Auckland; but I am not aware of above one or two seams at most in that district.' Considering, then, the uncertainty of supplies of coal from under the magnesian limestone,—that a large portion of the best Tyne coal district is exhausted; that the excavations in the best seams of the Wear are now very extensive,—that, in fact, the best part of the coal in the neighbourhood of the navigable parts of both rivers is gone, and that so many of the best seams crop out within a short distance of the west bank of the Wear, he is inclined to think that Mr. Taylor was far beyond the mark when he spoke of the probability of the coal of Northumberland and Durham lasting 1,700 years. He then adds these words: 'I am myself convinced, that with the present increased and increasing demand for coal, four hunhundred years* will leave little more than the name of our best seams; and when they are gone, those who are living will find London supplied from the great Welsh and Scotch coal fields at a cheaper rate.' He then goes on to state, that our northern coal field will probably be on the wane before three hundred years have elapsed; that is, in reference to the other

* An intermediate period has been assigned by Messrs. Bailey and Culley' who, in their general view of the district, estimate the duration of the coal at eight hundred and twenty-five years. The minimum amount is probably that given by Dr. Mac Nab, who estimates the extent of the coal fields in Northumberland and Durham at 20 miles by 15=300 square miles, computing, at the same time, that one square mile is equal to the consumption of a year.

coal fields, by which the London market will by that time, begin to be partially supplied. There is one circumstance stated in this letter," adds Mr. Sedgwick, "which I may just allude to: A great deal of coal appears formerly to have been left underground in consequence of a want of general plans or maps of the workings; a number of excavations have taken place independently of each other; and the consequence is, there is a great number of piers or large barriers between the old coal works, some of which it may be almost impossible to remove."*

The learned Professor, in reducing the estimated supply of coal from 1700 to 400 years, must be understood as speaking of those good beds mostly worked for the metropolis and for exportation, and the exhaustion of which, he assumes, will transfer the London trade to South Wales, where the coal is not of so good a quality as that of Newcastle, neither can it be at present so cheaply conveyed to the metropolis. The coals in the northern districts may last as long, or even longer than Mr. Taylor supposes, if we take in all those impure beds that may hereafter be excavated by persons resident on the spot for the use of their own households: and of course, the thin coal—all the little beds of six or seven inches would be got out, before the workings were finally given up. Professor Buckland agrees in the main with Mr. Sedgwick, and thinks the result of Mr. Taylor's calculation "egregiously exaggerated." Mr. Buddle, an individual probably better acquainted with the coal district on the Tyne, than any other person,—but a decided advocate for an unlimited foreign vend,—declined, when examined before the Committee of the

* Evidence before House of Commons, 1829, fol. 232.

House of Commons, to commit himself by any loose answer to the question as to how long, according to the present rate of consumption, the coal fields in Durham and Northumberland would last? "because," says he, "it may be ascertained." Indeed, this intelligent viewer expressed himself as confident of being able to reduce the whole to actual measurement and calculation* in a month: and this, he observed, might be done with reference to certain districts, so as to avoid the obvious objections which the coal owners would have to the publication of details relative to their particular sections.

Dr. Thomson, of Edinburgh, published some years ago, a series of calculations on this subject; and still later, Mr. Bakewell in his popular work on Geology, discusses the question of coal, and the period when the coal mines of England will probably be exhausted. This competent and ingenious observer says,—"We cannot but regard the exhaustion of our coal beds as involving the destruction of a great portion of our private comfort and national prosperity. Nor is the period very remote when the coal districts, which at present supply the metropolis with fuel, will cease to yield any more. The number and extent of the principal coal beds in Northumberland and Durham is known; and from these data it has been calculated that the coal in these counties will last 360 years." Mr. Bailey, in his survey of Durham, states, that one-

* It has been laid down as a rule, that "a cubic yard of coal will produce eight bolls of coals, each boll containing eight pecks of four and a half gallons, and each gallon containing 2688 cubic inches. Therefore, from that rule, an acre of coal stratum, one foot thick, will produce (if all got) thirty-one tens, each ten containing 420 coal bolls; or that acre will produce 1510 tons: consequently, an equal area of stratum, 2, 3, 4, &c. feet thick, will produce 2, 3, 4, &c. times the quantity of tens or tons of coal that a seam of one foot thick will produce."—*Fenwick's Subterraneous Surveying*, p. 202.

third of the coal being already got, the coal districts will be exhausted in 200 years. It is probable, that many beds of inferior coal which are now neglected, may, in future, be worked, but the consumption of coal being greatly increased since Mr. Bailey published his survey, we may admit his calculation to be an approximation to the truth, and that the coal of Northumberland and Durham will be exhausted in a period not greatly exceeding 200 years. Dr. Thomson, in the Annals of Philosophy, has calculated, that the coal of these districts, at the present rate of consumption, will last 1000 years; but his calculations are founded on data manifestly erroneous, and at variance with his own statements. Dr. Thomson has also greatly over-rated the quantity of coal in these districts, as he has calculated the extent of the principal beds from that of the lowest, which is erroneous; for many of the principal beds crop out before they reach the western termination of the coal fields. With due allowance for these errors, and for the quantity of coal already worked out, (say one-third) the 1000 years of Dr. Thomson will not greatly exceed the period assigned by Mr. Bailey for the complete exhaustion of coal in these counties, and may be stated at 350 years.

"It cannot be deemed uninteresting," proceeds Mr. Bakewell, "to enquire what are the repositories of coal that can supply the metropolis and the southern counties, when no more can be obtained from the Tyne and the Wear. The only coal fields of any extent on the eastern side of England, between London and Durham, are those of Derbyshire, and those in the West Riding of Yorkshire. The Derbyshire coal field is not of sufficient magnitude to supply, for

any long period, more than is required for home consumption, and that of the adjacent counties. There are many valuable beds of coals in the western parts of the West Riding of Yorkshire, which are yet unwrought; but the time is not very far distant, when they must be put in requisition to supply the vast demand of that populous manufacturing county, which at present consumes nearly all the produce of its own coal mines. In the midland counties, Staffordshire possesses the nearest coal district to the metropolis of any great extent; but such is the immense daily consumption of coal in the iron furnaces and foundries, that it is generally believed this will be the first of our own coal fields that will be exhausted. The thirty feet bed of coal in the Dudley coal field is of limited extent, and in the present mode of working it, more than two-thirds of the coal is wasted and left in the mine. If we look to Whitehaven, or Lancashire, or to any of the minor coal fields in the west of England, we can derive little hope of their being able to supply London and the southern counties with coal, after the import fails from Northumberland and Durham. We may thus anticipate a period not very remote, when all the English mines of coal and ironstone will be exhausted.

"Fortunately, however," Mr. Bakewell adds, "we have in South Wales, adjoining the British Channel, an almost exhaustless supply of coal and ironstone, which are yet nearly unwrought. It has been stated that this coal-field extends over about 1200 square miles, and that there are twenty-three beds of workable coal, the total average thickness of which is ninety-five feet, and the quantity contained in each acre is 100,000 tons, or 65,000,000 tons per square mile.

If from this we deduct one half for waste, and for the minor extent of the upper beds, we shall have a clear supply of coal equal to 32,000,000 tons per square mile. Now if we admit that 5,000,000 tons of coal, from the Northumberland and Durham mines, is equal to nearly one third of the total consumption of coal in England, each square mile of the Welsh coal-field would yield coal for two years' consumption; and as there are from 1,000 to 1,200 square miles in this coal field, it would supply England with fuel for 2,000 years after all our English coal mines are worked out. It is true, that a considerable part of the coal in South Wales is of an inferior quality, and is not at present burned for domestic use; but in proportion as coals become scarce, improved methods of burning it will assuredly be discovered, to prevent any sulphureous fumes from entering apartments, and also to economise the consumption of fuel in all our manufacturing processes."*

* Bakewell's Introduction to Geology, 1828, p. 178, et seq.

CHAPTER XXV.

FOREIGN COAL DEPOSITS.

Importance of Foreign Coal Deposits to Great Britain—General Phenomena of the Carboniferous Strata similar in different Countries—Organic Remains and accompanying Rocks—Independent Coal Formation of Werner—Occurrence of Coal in Spain—Near Dresden—In Silesia—Vast Deposits in France—In Belgium—Fire Damp—Coal Fields of Germany—Fossil Fishes—Coal in Sweden, Norway, and Poland—Immense Depositories of Anthracite and Bituminous Coal in North America—Scarcity of Fuel in some parts of South America—Rhode Island, Canada, and Australia contain Coal—Strata on Fire at Cape Breton—European Localities of Lignite and Fossil Wood.

ALTHOUGH the design of the present work, as to its more immediate bearing, might be considered as completed by the foregoing Chapters, a few brief notices of one branch of the subject in reference to other countries may be appropriately introduced in conclusion. The subject of foreign coal deposits is by no means one exclusively interesting to the geologist; it involves important considerations of a

commercial nature in relation to Great Britain. For, not only must the coal trade of this country be in some degree influenced by competition with the supply of so important an article from other and remote sources; but the districts containing coal mines, may be expected, hereafter, to become, in certain cases, the seats of manufactures, perhaps rivalling in importance, or it may be, surpassing those which, owing to the abundance and accessibleness of our fossil fuel, this country has long carried on so advantageously.

It has been remarked, that the great coal formation appears to abound most under the polar circle, and in the two temperate zones, but it is rarer towards the equator: a geographical distribution supposed to be connected with its formation. Although, as might be expected, the carboniferous strata, when viewed on the large scale, occasionally present some anomalies, as compared with the corresponding series in our own country,—yet still, the similarity in certain striking particulars is much more common and remarkable. This is more particularly manifest in the occurrence of sandstone and bituminous shales, or beds of compressed and indurated mud; together with those vegetable impressions which, although exhibiting specific differences from those met with in Britain, belong, for the most part, to analagous types.

We have already adverted to the opinion of M. Brongniart, that at the epoch of the coal formation, there existed eqiseta, or horse-tail plants, upwards of ten feet high, and six inches in diameter; tree-ferns, of from forty to fifty feet in height; and arborescent lycopodiacea, of from sixty to seventy feet high. Of the above classes of vegetables, as Mr. Lyell observes,

the species are all small at present, in cold climates; while, in tropical regions, there occur, together with small species, many of a much greater size; but their development at present, even in the hottest parts of the globe, is inferior to that indicated by the petrified stems of the coal formation. If the gigantic size and form of these fossil plants are remarkable, still more so is the extent of their geographical distribution: for impressions of arborescent ferns, such as characterize our English carboniferous strata, have been brought from Melville Island, in lat. 75°*.

The geological equivalent of our great carboniferous group of rocks, as met with on the continent of Europe, is what is called by the disciples of Werner, the Independent Coal Formation. It does not occur in the Alps, or in the basin of the Po; indeed, it is asserted, that the true coal measures do not exist in Italy; and this remark has, by some persons, been hastily extended to Spain and Sicily. Opinions, on this point, exhibit, as might be expected, various discrepancies, as geological enquiries have hitherto been limited, if not in their range, certainly in the number of scientific stations, and accredited observers at remote places; while travellers and geographers have commonly used the term "coal," in the most loose and popular sense.

As already intimated, the coal strata in Europe do not always conform to British analogies; and in some localities there seems so little agreement, that individuals pretending to geological acuteness have been misled thereby. In Spain, coal deposits are known in Andalusia, Estremadura, Catalonia, Arragon, and Castile, and the Asturias: but the beds are commonly thin, and the workings, for the most part, of little im-

* Principles of Geology, vol. i. p. 101.

portance: it seems, however, that one exception must be made with reference to the last-named locality, where the beds which are described as "vast," and supposed by Professor Hausman to be subordinate to the immense iron-stone hills near Bilboa.* In Portugal, there are some trifling coal works. True coal measures exist at Postchapel, near Dresden, at Friedland, and near to Ternovitz, in Silesia; in the latter place, there are vast deposits of valuable fuel; as also at Namur, Saare Brooke, and St. Etienne in France.

One of the richest deposits of coal that is known, forms the nearly continuous series of coal basins placed in a belt about one hundred and fifty miles long, and six miles broad, which crosses the north of France, containing the coal mines of Valenciennes, Conde, Mons, Namur, Liège, and at the last-named place, the measures are said to comprise eighty-three beds.† They produce annually more than seventy millions of quintals of coals, worth thirty millions of francs; and they employ about thirty-five thousand colliers.

In 1826, it was stated in the *Annales des Mines*, that about forty departments were known to contain coal, and a list of the localities is given in that work.‡ Several of the deposits, however, it was admitted, could scarcely be said to be more than known; others

* In Spain, charcoal is commonly used for fuel both in the kitchen stoves upon which culinary operations are performed, and in the *brasero's*, or warming pans, placed to air the sitting rooms. The mountains of New Castile, which are covered with noble trees, supply the inhabitants of the plains, and also the capital with charcoal for fuel; and it is common in the streets of Madrid to meet with asses bearing large panniers of this commodity, accompanied by a boy shouting "carbon! carbon!"

† These localities of foreign coal are mostly derived from Phillips and Conybeare, Dr. Ure, and Mr. De la Beche.

‡ Edin. Phil. Journ. vol. xiv. pp. 252-257, where the account is translated from the Periodical above cited.

were worked to a small extent. The produce of two hundred and thirty-six mines was estimated at that time, at from nine to ten millions of quintals annually, or about one-eighth of the yearly consumption of England. The number of miners employed is stated to have been, in 1826, about seven thousand. A strong prejudice, as elsewhere mentioned, existed, and still exists, against the use of pit coal for domestic purposes. Otherwise, it is stated, the mines in the department of Aveyron alone, might, from their extreme richness, have supplied the whole of France with fuel; yet, the quantity annually extracted from them was only about ten thousand quintals; and this from thirty different mines by superficial works, conducted without any rule.*

According to the authority above quoted, there were in Belgium, in the neighbourhood of Mons, Charleroi, and Liege, three hundred and fifty mines, giving employment to twenty thousand workmen, and producing annually about twelve millions quintals of coal. In general, the coal seams are interstratified with beds of sandstone and schistose matter, similar to those which characterize the measures in our own country. They are, however, much more singularly contorted, especially at Anzin, near Valenciennes; the strata, being in some cases, apparently folded backward and forward, "thus forming an enormous bale, half a league broad, and several leagues long." The mines, just without the gate of the city of Liege towards Brussels, are about one hundred and twenty

* In France, about one tenth of the iron, i. e. 17,000 tons, is smelted with coke; the other nine tenths, with charcoal. Wood being used for this, as well as for domestic purposes, in many parts of the country, the consumption, as may be supposed, is immense: and not less than fifteen or sixteen millions of acres are occupied by woods and forests.

fathoms deep: they are exposed to similar accidents from irruptions of water, fire damp, &c., to those in Great Britain. In 1812, owing to a sudden influx of the water, while one hundred and twenty-seven colliers were at work, seventy-four of the number, (the rest having escaped) were only saved, after suffering dreadfully, by means of a communication cut to them from an adjacent drift, through a space of about one hundred and twelve feet. By the adoption of the Davy safety lamp, they early shared the advantages, and reiterated the gratitude of the pitmen of our own country.*

Germany contains several great deposits of coal, particularly in Saxony, Bohemia, and Silesia; the last-named province containing more than one hundred mines. In Austria, Tyrol, Bavaria, Hanover, the Hartz, and Hungary, there are mines of coal, though to what extent, or of what quality, we are not particularly informed. Thuringia is remarkable for the presence of a bituminous cupriferous schist, which contains a great quantity of fishes crushed, and even converted into a species of coal, which is occasionally

* In Dr. Paris's Life of Sir Humphry Davy, there is a notice of a pamphlet which appeared at Mons, in the year 1818, on the explosions that occur in coal mines, and on the means of preventing them by Davy's Safety Lamp. It was published under the direction of the Chamber of Commerce and Manufactures of Mons, accompanied by notes, and by the result of a series of experiments that had been conducted by M. Crossart, President of the Chamber. The province of Hainault is said to be richer in coal mines than any other part of the Continent of Europe, and to have no less than one hundred thousand persons employed in the working them. The same kind of dangerous accidents occurred in these mines as in those of the north of England, and various expedients had been adopted for their prevention, which, however, availed but little in obviating them. "All the precautions," observe the reporters, "which had been hitherto known or practised, had not been able to preserve the unfortunate miners from the terrible effects of explosion. It is, therefore, an inappreciable benefit which we confer by making known the equally simple and infallible method of preventing these accidents, which has been discovered by the celebrated Humphry Davy."

used for fuel; thereby demonstrating the possibility of the carbonaceous transmutation of even animal matter; a fact, indeed, of which we have evidence in our own country.* The Netherlands, it appears, owe their geological connexion with Germany, to a chain of carboniferous rocks.

Coal is comparatively rare in the north of Europe, as in Sweden and Norway—countries so rich in mines of other kinds; they, however, abound with pine forests, so that fuel for the smelting of their ores is sufficiently abundant. In Poland, the coal measures are stated to repose on a black marble used in the arts: they contain numerous impressions of plants.

Mr. De la Beche quotes an authority for the existence of a rich carbonaceous deposit in the mountains which extend for a distance of 150 wersts, on the right bank of the Donetz, in Southern Russia. The coal is described as occurring in beds from a few inches to seven feet in thickness; and as being bituminous among the sandstones and shales, but becoming anthracite where the rocks pass into grauwacke. Coal has been mentioned as wrought in Siberia.

There is said to be an abundance of excellent coal in China and Japan, some provinces in the Celestial Empire being as rich in this mineral as any countries in the world: of its quality and geological collocation, we have little information. India† is by no means

* The coal of Poictiers, in Dauphiny, yields on distillation a large quantity of ammonia. It contains numerous sea shells, and even the bones of animals, to which probably some of its substance is due. But as this does not occur in a genuine coal formation, it cannot be regarded as a true pit-coal.—*Ure's Geology*, p. 168.

† The diamond is said to have been found in the Coal Formation of India—though not actually in the coal seams. It may be mentioned by the way, that in terming coals "Black Diamonds," as is often jocularly done when speaking of the produce of our collieries, there is more propriety in

deficient in coal; the most famous field is that of Damuda, discovered in 1815, and composed of various beds of bituminous coal of good quality, alternating with shales, sandstone, &c.* At Ramjung colliery, eight beds, varying from four inches to nine feet, are worked. The coal is not, however, confined to these districts, but extends east and west of Damuda to the distance of several hundred miles.† Coal is known to exist in the Island of Madagascar; and also in Africa, though to what extent we are not informed.

America‡ contains some immense coal deposits,

the appellation—especially when applied to anthracite, which contains so large a proportion of carbon, than the user may be aware. "It will naturally," says Dr. Kidd, "excite the surprise of those who are unacquainted with the chemical history of this substance, to learn that the purest diamond does not essentially differ from a particular variety of common coal."—*Physical Condition of Man. Bridgewater Treatises.* Nor is it unworthy of notice, that Dr. Brewster, in a communication to the Geological Society, inclines to the opinion that the diamond itself may be of vegetable origin.

* In the Edinburgh Philosophical Journal, for 1832, p. 347, there is a table giving the results of several analyses of Asiatic and New Holland coals, comprising thirty sorts, made at the Calcutta Assay Office, from which it would appear that most of the Indian coals are totally unfit for the purposes of making coke. The Burdwan coke, with the exception of one specimen, would contain nearly a quarter of its weight of earthly impurity; the Silhet would be still worse; the coal of Baghelpúr, (which Mr. Jameson seems to suspect is mistakenly called anthracite), would be nearly half earth; some of the mountain coal from Ava would yield a coke of better quality, but of very little density. The Chinese glance-coal alone forms a remarkable exception to this unfavourable conclusion against Oriental coal, and deserves to rank at the head of the list in respect to its purity as a coke, although in specific gravity it does not come up to the character of the English fuel, neither has it the spongy texture which contributes much to the glowing combustion of the latter.

† It is stated that among the MSS. left by the late Major James Franklin, F.G.S., there is an account of the different beds of coal as well as of iron mines in the Central Districts of India.—Phil. Mag. July, 1835.

‡ The common fuel in the cities and towns of the United States, consists chiefly of wood, of which there are various kinds: the best is the celebrated hiccory tree, which commonly fetches a price equivalent to about twelve shillings per load; it is a durable fuel, and does not soon die out; oak billets are next in esteem, and sell for nine shillings; gum wood, dog wood, and

both of anthracite and the bituminous kinds. That great magazine of coal which shall hereafter be opened up for the supply of the United States, lies mostly under those vast plains or steppes extending from the western slope of the Alleghany mountains to what are called the "Sand plains," a distance of 1500 miles, and from the Northern lakes to the mouth of the Ohio, a width of nearly 600 miles. This immense tract embraces the States of Ohio, Indiana, Illinois, Missouri, Kentucky, and parts of Pennsylvania, Virginia, Tennessee, Arkansas, and Michigan, as well as a wild region of about 500 miles wide lying to the west of these States. According to an American writer,* "The formation of these plains is decidedly secondary, reposing on a horizontal limestone rock, the thick strata of which have never been penetrated. This limestone pan (as it is called), is generally but a few feet below the surface, and supports strata of bituminous coal and saline impregnations through almost its whole extent. The mineral resources of these plains are unbounded, and *its coal-field would cover half Europe.* The coal is pure, lies above the river channels, and is easily worked. Iron and lead are also abundant." The measures occurring at Carbondale, Lehigh,†

pine wood, are an inferior description of firing, and fetch six or seven shillings the load, according to circumstances. The quantity to be accounted a load is fixed by law; and the logs, which are about four feet long on the cart, are sawn into short billets previous to being piled in the cellars of the consumer, by the hawker of the fuel, or some person who accompanies him with a saw on his back. The poor mostly burn fagots, or pine wood. For charcoal, the wood of the tulip tree, (*Liriodendron tulipifera*) is much used in the United States.

* Illinois Monthly Magazine.

† The Lehigh or "Peach Orchard" coals, are stated to sell at Philadelphia at £1 10s. per ton; in New York, and other distant places, the expenses of carriage increase the price of the commodity to about £2 per ton sterling.

Lackawaxen Wilksbarre, and other places in the United States, are referred to the same era of deposition as the carboniferous series of Europe: the geological relations of the strata, however, differ, sometimes considerably, from what is observed in our British coal-fields. The organic remains, so far as lists of them have been published, generally resemble those which have been found in Europe. Fossil fish, preserved like those of the copper shale in Thuringia, and in the magnesian limestone of England, are found in the bituminous schists at Westfield, in Connecticut, and at Sunderland, in Massachusetts. At Wilksbarre, the coal is mostly from twelve to fifteen feet thick—sometimes thirty or forty feet: it is interstratified with beds of shale and sandstone; some of the latter being from five to one hundred feet in depth. The celebrated Anthracite of Pennsylvania extends, as we are informed by Mr. Eaton, along the foot of the Catskill Mountains, and is continued from the southern part of Pennsylvania to Sackett's Harbour on Lake Ontario.* In Rhode Island, (Connecticut,) has been found a quantity of Anthracite, with which Professor Silliman has made comparative experiments, in reference to the Anthracite of Pennsylvania.† He found that it gives out an equal

The Newcastle coal sells on the average for about £3 per ton; and the Lancashire cannel coal about 10s. additional at the above places. The discovery of coal in Pennsylvania has been the occasion of sudden good fortune to some: one individual, who had a piece of land, for which he gave about one shilling sterling per acre, afterwards sold it for three hundred dollars per acre! The local appellation by which the coals are known, originated in the circumstance of their being brought to Philadelphia by the Lehigh canal.

* Silliman's American Journal of Science, vol. xix.

† The terms anthracite and bituminous, as applied to coal, although indicating substances sufficiently distinct in different places, or at opposite extremes of a coal field, may, nevertheless, apply very equivocally to inter-

volume of inflammable gas, and burns without difficulty in furnaces built with fire-proof bricks. It burns with a considerable red flame, and with a very intense heat. Its colour is steel-grey, and much resembles plumbagine. The surface is sometimes covered with a thin pellicle of this substance; and small particles of genuine plumbagine are accidentally met with among the schists which accompany it. It sounds semi-metallic, and is somewhat of a slaty structure.*

There is abundance of excellent coal, as well as iron, copper, and lead, in the colonies of Nova Scotia, Cape Breton, New Brunswick, and Australia. With

mediate masses, and more especially to the whole deposit. In fact, a bed of coal, that is sometimes decidedly inflammable in one situation, so far loses its bitumen in another, that the mass becomes almost altogether carbon. As examples, the great coal deposit in Connecticut is sometimes called anthracite, and at others described as bituminous, by American geologists. Mr. de la Beche states, that the continuous coal deposit of South Wales is anthracite in Pembrokeshire, and bituminous in its eastern prolongation through Monmouthshire. Nor is the occurrence of coal in contact with the primary rocks confined to anthracite, the bituminous deposit of Virginia rests on granite, and the coal series of France is, in some places, deposited on gneiss, mica-slate, &c.

* Although in most parts of North America, the immense forests furnish inexhaustible supplies of fuel, it is far otherwise in many parts of South America, where, instead of trees, the forests—for so they may be called—consist of vast tracts of grass, not, of course, available for economical firing; this is especially the character of the country about Buenos Ayres, where there is scarcely a tree to be seen for many miles; and from such a distance has fuel to be carried, that it has been affirmed there is scarcely a burden of fire-wood brought into that city, which is not literally worth more than the beast which carries it. While mentioning South America, it may be added, that in a work lately published by a Spaniard, there is a comparison between the produce of the gold and silver mines of America and the coal mines of England, in which the author exhibits a balance in favour of the latter, of no less than 229,500,000 francs annually! And this without taking into the account that almost entire destruction of the soil which generally takes place in the search after the precious metals in the new world; while in Great Britain, the subterranean riches are extracted, where beautiful harvests of golden grain, or verdant meadows, are conspicuous over nearly the entire tracts of operation.

the working of the mines at the former place, important commercial results will no doubt, at some future period, be identified: and, perhaps, the local authorities have not regarded without suspicion, the geological surveys of the island which have been made by individuals belonging to the United States. Williams, in his Mineral History, contended at great length for the expediency of Great Britain working the coal, which, in his time, was understood to abound in the island of Cape Breton, as well in order to raise revenue, as to diminish the quantity exported from this country to America and the West Indies.

Coal as well as iron abound in the interior of Australia; the coal is not so bituminous as ours: it burns clearly and rapidly, and is getting daily more into demand at Sydney, accordingly as wood becomes more scarce. It can be had at the pits' mouth for five shillings a ton, but the expenses of carriage raise it to twenty shillings at Sydney. It was recently stated in the public journals, that a valuable discovery had just been made by the Rev. Mr. Threlkeld, at Lake Macquarrie, in the district of Reid's Mistake. He was about to build a chimney, with what he considered to be a very fine black stone, which he had found in abundance in the neighbourhood of his dwelling: when, upon close examination, he ascertained it to be, what is called in England, cannel coal. Competent judges, it is stated, have declared the coal to be of very superior quality. The seam lies almost at the surface, and can, therefore, be worked at a trifling expense. First comes a layer of inferior coal, three feet thick; this is immediately succeeded by another layer of excellent quality, about five feet thick, and which, so we are assured by the

report, can be taken up in solid masses of a yard square.

It may be added, that some of these remote coal deposits have been on fire—perhaps occasioned by lightning: one recent instance has been already noticed;* and we are informed by the Abbe Raynal, that a seam of coal was once set on fire at Cape Breton, which burned with great fury. In the London and Edinburgh Philosophical Magazine, for August, 1832,† there is a description and sketch by the Rev. C. P. N. Wilton, of certain burning cliffs on the south-east line of coast near Newcastle, in Australia. This writer describes the cliffs as rising to the height of from one hundred to three hundred feet above the sea; their surfaces presenting in some places, *three*, and in others, *two* parallel beds of coal "of the independent formation." Large stems of arundinaceous plants in ironstone appear in great abundance between the horizontal beds of coal and the other strata. At no great distance from one of the cliffs on this coast, which was discovered, August, 1830, to have been on fire at no distant period, beneath a stratum of breccia, varying from eight to thirty feet in thickness, a bed of *brown* coal reposes, which passes into black, having immediately above it an accumulation of arundinaceous plants mixed with petrified wood.

Various species of fossilized wood, brown coal, or lignite, (sometimes, however, so perfectly bituminous and compact, as hardly to be distinguishable from the true coal, but belonging to an era subsequent to that at which the "independent formation" took place,)

* In the coal formation on the banks of the Mackenzie River, which extends as far as 70° north lat. and supposed by Dr. Richardson to be identical with that in the county of Sutherland, in the north of Scotland.

† Page 93.

occur in vast quantities in Europe and elsewhere, serving, in some instances, as valuable fuel. In the valleys of the Po, the Danube, in Switzerland, in the great basin of Paris, as well as in various other places, and comprehended among the tertiary formations, there are immense beds of lignites, sometimes approaching to glance coal, of an excellent quality, and upon which pits are worked. This wood coal of various kinds, is much used in some parts of the Continent as fuel for ordinary purposes: and its frequent and abundant occurrence in situations remote from the true coal, give it a much more important relation to the wants and conveniences of the inhabitants of other countries than can well be conceived of, by merely regarding the value of analagous deposits in Great Britain.

Lignites occur abundantly in oolite passing into coal at Carpona, and in the island Veglia, where they are excavated for the use of the Trieste steam boat. The lignite mines of Buda, in Hungary, are remarkable for the supply of fuel which they afford. It seems to be admitted by Brongniart, that the supposed coal of the south of France is a lignite formation. There are extensive mines of this substance in Provence, about Marseilles and Toulon, where twenty-eight beds are wrought. The principal deposit at Cologne is thirty feet thick: this is also the locality of the pulverulent variety so valuable in painting. Lignites abound at Soissons, Epernay, Laon, St. Paulet, and some other places in France. To the lignite above the chalk, are supposed to belong those immense deposits found in the middle of the Alps, and those of Styria, mined for fuel.*

* Ure's Geology, p. 173.

In 1828, a large mass of fossil wood was discovered upon one of the gulphs of the Danube, named Yalpong, in the lower part of Bessarabia, and opposite the town of Belgrade. This fossil was considered likely to become of importance to that part of Russia, now entirely deprived of forests. The lignite is in the form of fossil masses, of a greyish colour, but passing, in the lower portions, into a deep black. In the upper parts, are found quantities of the *débris* of wood, covered with bark, white, thick, and friable; the pieces pressed one upon another, and intermixed with the husks of grain *(cosses de céréales)*. The wood, according to the discoverer, Mr. Lichfeldt, is that of the lime tree. It lies nearly horizontal between coarse sand and calcareous clay; the first in the form of a wall, and the latter serving as a roof, in which many shells occur. The sand is separated from the stratum of lignite by about six inches of a resinous clay, in the lower part of which a great number of shells of different sorts are found.

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THE END.

SHEFFIELD:

PRINTED BY GEORGE RIDGE, KING-STREET.